THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. VIII.—AUGUST, 1889.

ORIGINAL ARTICLES.

I.—The Lias Marlstone of Tilton, Leicestershire.

By E. Wilson, F.G.S., and W. D. Crick,
With Palæontological Notes by E. Wilson, F.G.S.

(PLATE X.)

(*Concluded from the July Number, p.* 305.)

Cardinia Slatteri, Walford, 1878. Plate X. Figs. 1, 2.

1878. *Isocardia? Slatteri*, Walford, "On some Middle and Upper Lias Beds in the Neighbourhood of Banbury," Proc. Warwick Nat. and Arch. Field Club, 1878, p. 49. 1879. *Isocardia*, sp. in reprint of same paper, pp. 16, 20, fig. 5 in plate.

Description.—Shell trigonal, thick; umbones large, angulated and terminal, ending in acute points, which curve downwards, forwards, and a little outwards; the sides of the shell, triangular in form, slightly excavated and highly inclined to the areas, are bounded by prominent carinæ, an acute carina separating the side from the slightly concave triangular area in front, and a more rounded carina separating it from the slightly convex triangular area behind. The valves are marked with strongly defined and somewhat sinuous sub-imbricating lines of growth at wide and fairly regular intervals, between which may be discerned numerous fine lines of growth. Lunule small and deep. Cardinal tooth elongated, oblique and prominent in the right valve, small and triangular in the left. Anterior lateral tooth of right valve obtusely conical and very prominent, received into a deep socket in the corresponding valve, immediately above the impression of the anterior adductor muscle; posterior lateral tooth in left valve elongated, longitudinally grooved and attenuated towards the umbo; muscular impressions deeply sunk into the substance of the shell, the anterior triangularly ovate, the posterior oval-oblong; pallial line not discernible in specimens examined; ligament external, groove for its insertion elongated, shallow and curved concentrically with the dorsal margin of the shell. Height of shell, 18 to 25 mm.; breadth, 21 to 29 mm.

Note.—This shell has somewhat the form of an *Opis*, and is very like *Opis Ferryi*, Dumortier (Dépôts Jurassiques, pt. 3, p. 264, pl. xxx. fs. 4–6); but it differs from that shell by its more strongly curved outlines, absence of longitudinal ribs, and larger size. Possibly that form, as well as certain other trigonal bicarinated shells having imbricating growth layers—and the hinge characters

of which have not been noticed—may eventually be found to fall under the genus *Cardinia*.

This fossil was first discovered by Mr. E. A. Walford, F.G.S., in the Marlstone and Middle Lias Transition-bed of Aston-le-Wall and Appletree, Northamptonshire, and referred to in this author's paper above cited, and figured but not described in the reprint of same, under the name *Isocardia Slatteri*, Walford. At that time the hinge characters had not been made out, and consequently the generic identification was made with some diffidence. Mr. Crick has since found an almost perfect left valve of this shell on the East Norton embankment, and Mr. Walford has kindly lent me a right valve, in which also, now that the matrix has been cleaned out, the hinge characters are clearly displayed (see Pl. X. Fig. 2). These hinge characters are essentially those of a *Cardinia*, as also is the mode of growth, and to that genus I therefore without hesitation refer this shell, and in this view Mr. Walford concurs.

Marlstone Rock, Tilton (East Norton embankment).

Pinna Tiltonensis, sp. nov. Plate X. Fig. 3.

Shell elongated, lanceolate, anterior and posterior borders with nearly straight edges, but slightly convex; with concentric longitudinal plicæ, which towards the umbo become broken up and mammillated; the posterior half of each valve is ornamented with slender radial costæ, which are regular and equally spaced except the two lower or median ones, which are more slender and wider apart; about half only of the radial costæ reach the ventral border of the shell; these radial striæ, where they cross the plicæ of growth, form a neat meshwork, and are as a series interrupted at intervals, where they take an oblique direction for a short distance so as to present a distorted appearance. We have two examples of this shell; both are incomplete, and the best-preserved specimen which is figured is very much compressed; hence the materials for founding a species are not the most satisfactory, and the above name must be considered therefore as provisional.

Marlstone Rock, Tilton (East Norton embankment).

Inoceramus, sp. Plate X. Figs. 4, 4*a*.

Shell markedly inequivalve, moderately inflated, longer than broad, broadly flattened posteriorly in the left valve, acuminated towards the umbones, which are prominent, pointed, approaching and recurved; the valves are marked with irregular longitudinal ridges and furrows, and finer concentric lines of growth, and by rather ill-defined and irregular radial striæ, which at their intersections give an irregularly mammillated and pitted aspect to portions of the shell. This shell differs in its form and markings from all the Jurassic *Inocerami* with which I am acquainted; but having only a single and incomplete specimen, I hesitate to impose a new name. Should it eventually appear that we have here a new species, the name *Inoceramus Tiltonensis* might be given to it.

Marlstone Rock, Tilton (East Norton embankment).

EODIADEMA GRANULATA.

The beautiful specimens of this Middle Lias Echinoid belong to a new genus, the description of which will be found in "A Revision of the Genera (Fossil and Recent) of the Echinoidea." Journ. Linn. Soc. vol. xxiii. 1889, by Prof. P. Martin Duncan, F.R.S., etc. The following is the diagnosis.

Genus *Eodiadema*, Dunc. 1889.

Test small, thin, circular in tumid marginal outline, sub-conical dorsally, tumid and reentering actinally, broader than high. Apical system moderate in size, ovoid or elliptical in outline at the periproct: five large basal plates, four in contact, but the fifth or posterior separated from the others on either side by radial plates, which thus enter the ring. Ambulacra narrow, straight, wider than the interradia at the peristomial margin, narrower elsewhere; poriferous zones narrow, pairs of pores numerous, in single, simple, vertical series, barely any crowding near the peristome; plates all low broad primaries; interporiferous areas rather broad, crowded with blunt granules dorsally, some larger granules near the poriferous zones, and giving place at the ambitus to some very small crenulate perforated tubercles, which diminish actinally. Interradia broad, plates not numerous, broader than high; two vertical rows of perforate, crenulate and scrobiculate tubercles in each area, a few large at the ambitus, and all becoming rapidly small and almost obsolete dorsally, or replaced there by granulation, diminishing also actinally. Scrobicules of the ambital tubercles large, usually coalescing. A large blunt granulation occurs beyond the scrobicular circles, except on angular median spaces contiguous with the basal plates where there are no granules. Peristome decagonal, sunken, small, with well-marked branchial incisions.

The position of this genus is in the family Diadematidæ and in the sub-family Orthopsinæ.

EODIADEMA GRANULATA, sp. nov. Plate X. Figs. 5, 5*a*, 5*b*, 5*c*.

Test small, sub-conical above the tumid ambitus, circular in ambital outline. Apical system with granulated basal plates, with large perforations; the posterior radial plates large, separating the fifth basal plate and entering the periprocteal ring; the others smaller, triangular and excluded. A raised rim around the periproct. Poriferous zones somewhat sunken; all plates simple primaries; tubercles very small in two vertical rows. Dorsal surface of interradia, except in the median lines down to varying distances towards the ambitus, very boldly granulate; in the triangular spaces, from the basal plates along the median lines there is but slight granulation or it may be absent.[1] About five large primary tubercles in each interradium at the ambitus, perforate, crenulate, and with coalescing scrobicules. Peristome reentering; with branchial incisions limited by raised lines. Height, 6 mm.; breadth, 12 mm.

Marlstone Rock, Tilton (East Norton embankment).

[1] The otherwise faithful drawing, Fig. 5*a*, should have fewer granules upon the interradial plates close to the basal plates.

ONYCHITES, sp. Plate X. Fig. 6.

Two of the peculiar bodies known by this name were obtained by Mr. B. Thompson, F.G.S., from the East Norton embankment.

The specimen here figured may be described as follows: Cylindrical curved hollow body tapering to a point at each end, somewhat constricted in the middle (3 mm. in diameter) and expanded towards the ends (4 to 5 mm. in diameter), and flattened and with acute edges towards one end; this body is bow-shaped, the points curving towards the same side, but in planes considerably inclined to each other; the pointed ends are about 4·5 centimetres apart; the shelly covering is thin, smooth and apparently structureless, but under a high-power lens its external surface appears to be finely punctated; the shell is separated from the surrounding matrix by a uniformly narrow hollow space about ·5 mm. broad, indicating apparently the former presence of a soft investing organic layer, which has disappeared in the process of fossilization. At first sight these hollow cylindrical bodies look as if they might have belonged to tubicolar Annelids; but it is to be observed that their tubes are closed at *both* ends, and that, as we have just seen, there are indications of their having been internal and not external structures.

Thirty years ago, Quenstedt described several of these curious bodies in "Der Jura."[1] At one time it appears they were taken for "compressed crabs-claws"! Dr. Fraas considered them to be the acetabular hooks of Cephalopods, referring them to *Onychoteuthis*, and in this view Quenstedt concurred. Messrs. Tate and Blake state in 'The Yorkshire Lias'[2] that they met with these pointed organisms in the 'Jamesoni beds' at Peak, agreeing with the *Onychites numismalis*, of Quenstedt, but they avoided any speculation as to their true nature. I am inclined to accept the explanation suggested by Fraas and Quenstedt.

Marlstone Rock, Tilton (East Norton embankment).

EXPLANATION OF PLATE X.

FIG. 1. *Cardinia Slatteri*, Walford. Marlstone Rock, Tilton (East Norton embankment). Left valve, exterior. Nat. size.

,, 2. *Ibid.* Marlstone Rock, Transition-bed, Appletree. Right valve, interior. Nat. size.

,, 3. *Pinna Tiltonensis*, sp. nov. Marlstone Rock, Tilton (East Norton embankment). Nat. size.

,, 4, 4*a*. *Inoceramus*, sp. Marlstone Rock, Tilton (East Norton embankment). Right and left valves. Half nat. size.

,, 5. *Eodiadema granulata*, sp. nov. Marlstone Rock, Tilton (East Norton embankment). Side view, enlarged twice.

,, 5*a*. *Ibid.* Apical system. Same locality. Enlarged six times.

,, 5*b*. *Ibid.* Mouth opening. From another specimen, enlarged three times.

,, 5*c*. *Ibid.* Ambulacrum and interambulacrum, enlarged six times.

,, 6. *Onychites*, sp. Marlstone Rock, Tilton (East Norton embankment).

[1] "Der Jura," p. 201, pl. 24, fs. 59–62, and pp. 246–7, pl. 34, fs. 2–5.

[2] "The Yorkshire Lias," p. 448.

APPENDIX.

List of Fossils from the Lias Marlstone (including the "Transition Bed") of Tilton, Leicestershire.

Reptilia.

Ichthyosaurus, sp. vertebræ.

Cephalopoda.

Amaltheus margaritatus, De Montf.
,, *spinatus*, Brug.
Harpoceras acutum, Tate.
,, *ovatum*, Young and Bird.
,, *serpentinum*, Rein.
Stephanoceras annulatum, Sow.
,, *commune*, Sow.
,, *semicelatum*, Simpson.
Belemnites apicicurvatus, Blainv.
,, *breviformis*, Voltz.
,, *clavellatus*, Bean.
,, *paxillosus*, Schloth.
Nautilus truncatus, Sow.

Gasteropoda.

Actæonina fragilis, Dunker.
,, *ferrea*, Wilson.
,, *Ilminsterensis*, Moore.
,, *sinemuriensis*, Martin.
Amberleya (*Trochus*) *Gaudryana*, d'Orb.
,, ,, ,, a var.
Cerithium confusum, Tate.
,, *costulatum* ? Desl.
,, *ferreum*, Tate.
,, *Ilminsterensis* ? Moore.
,, *liassicum*, Moore.
,, *reticulatum* ? Desl.
Chemnitzia (?) *Periniana*, d'Orb.
,, (?) (*Turritella*) *undulata*, Benz.
Cryptoenia expansa, Sow.
,, *rotelliformis*, Dunker.
,, *solarioides*, Sow.
Cylindrites æqualis, Wilson.
Monodonta bullata, Moore.
Pseudomelania (*Chemnitzia*) *Brannoviensis*, Dumort.
,, (*Phasianella*) *turbinata*, Stol.
,, sp.
Pleurotomaria (*Turbo*) *canalis*, Mü.
,, (*Trochus*) *helicinoides*, Roemer.
,, *rustica*, Desl.
,, *similis* (=*anglica*), Sow.
Trochus ariel, Dumort.
,, *Fidia*, d'Orb.
,, *lineatus*, Moore.
,, *Pethertonensis*, Moore.
,, *rotulus*, Stol.
Turbo cyclostoma, Benz.
,, *rugifera*, Moore = *T. coronatus*, Moore = *Pl. costulatum*, Moore.
,, *latilabrus*, Stol.

Lamellibranchiata.

Anomia numismalis, Quenst.
Astarte striato-sulcata, Roemer.
Cardinia concinna, Sow.
,, (*Isocardia*) *Slatteri*, Walford.
Ceromya bombax, Quenst.
Goniomya heteropleura, Ag.
Gresslya intermedia, Simpson.
,, *lunulata*, Tate.
Hinnites abjectus, Phillips.
,, *velatus*, Münster.
Inoceramus, sp.
Lima eucharis, d'Orb.
,, *Hermanni*, Voltz.
,, *pectinoides*, Sow.
Limea acuticosta, Münster.
,, *Juliana*, Dumort.
Macrodon Buckmanni, Buckm.
Modiola numismalis, Oppel.
,, *ornata*, Moore.
,, *scalprum*, Sow.
Monotis inæquivalvis, Sow.
Ostrea (*Gryphea*) *cymbium*, var. *depressa*, Lam.
,, *submargaritacea*, Brauns.
Pecten acutiradiatus, Goldfuss.
,, *æquivalvis*, Sow.
,, *calvus*, Goldfuss.
,, *dentatus*, Sow.
,, *lunularis*, Römer.
,, *priscus*, Schloth.
,, *textorius*, Schloth.
Pinna Tiltonensis, n.sp.
Plicatula spinosa, Sow.
Protocardium truncatum, Sow.
Tellina gracilis, Dumort.
Unicardium subglobosum, Tate.

Brachiopoda.

Discina reflexa, Sow.
Rhynchonella acuta, Sow. var. *bidens*, Phill.
,, *Amalthei*, Quenst.
,, *fodinalis*, Tate.
,, *tetrahedra*, Sow.
,, ,, var. *Northamptonensis*, Walker.
Spiriferina rostrata, Schloth.
Terebratula punctata, Sow.
,, ,, var. *Edwardsii*, Dav.
,, ,, var. *Haversfieldensis*, Dav.
,, *punctata*, var. *Radstockensis*, Dav.
,, *Walfordi*, Dav.
Waldheimia indentata, Sow.
,, *numismalis*, Lam.
,, *resupinata*, Sow.
,, *sub-numismalis*, Dav.

BRYOZOA.

Diastopora oolitica, Vine.
,, *stomatoporoides* ? Vine.

ANNELIDA.

Ditrupa capitata, Phil.
,, *etalensis*, Piette.
,, *quinquesulcata*, Münster.
Serpula tetragona, Desl.
,, *tricristata*, Goldfuss.

ECHINODERMATA.

Eodiadema granulata, n.sp.
Pentacrinus lævis, Miller.

ACTINOZOA.

Thecocyathus, sp.

INCERTA SEDIS.

Onychites, sp.

II.—SUBAËRIAL DEPOSITS OF THE ARID REGION OF NORTH AMERICA.

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Part II.

(*Concluded from p.* 295.)

A COMPARISON of adobe with the loess of China forms the concluding part of this paper; but as no analyses of the Chinese deposit are known to me, a few analyses of the loess of the Mississippi Valley are inserted, not with the assumption, however, that the deposits bearing the same name in these two regions are identical. A comparison of this table with the one showing the composition of adobe is instructive, as it indicates that these two yellow earths have a very similar composition. There are other respects in which they bear a close resemblance to each other; but as my acquaintance with the loess of the Mississippi Valley is limited, this comparison will not be carried further.

ANALYSES OF THE LOESS OF THE MISSISSIPPI VALLEY.[1]

Constituents.	No. 1.	No. 2.	No. 3.	No. 4.
SiO_2	72·68	64·61	74·46	60·69
Al_2O_3	12·03	10·64	12·26	7·95
Fe_2O_3	3·53	2·61	3·25	2·61
FeO	·96	·51	·12	·67
TiO_2	·72	·40	·14	·52
P_2O_5	·23	·06	·09	·13
MnO	·06	·05	·02	·12
CaO	1·59	5·41	1·69	8·96
MgO	1·11	3·69	1·12	4·56
Na_2O	1·68	1·35	1·43	1·17
K_2O	2·13	2·06	1·83	1·08
H_2O	*a*2·50	*a*2·05	*a*2·70	*a*1·14
CO_2	·39	6·31	·49	9·63
SO_3	·51	·11	·06	·12
C	·09	·13	·12	·19
	100·21	99·99	99·78	99·54

a Contains H of organic matter, dried at 100° C.

Organic Remains.—The fossils occurring in adobe, so far as I have been able to ascertain, are confined almost entirely to two classes, namely, land-shells and the bones of land-animals. Freshwater-

[1] From "The Driftless Area of the Upper Mississippi Valley," by T. C. Chamberlin and R. D. Salisbury, Sixth Ann. Rep. U.S. Geol. Surv. 1884–1885, p. 282.

shells are frequently present, but their number, so far as observed, is always small in comparison with the associated land-shells.

Samples of adobe collected near Fort Wingate, N.M., contained the following fossils, as has been kindly determined for me by William H. Dall, who states that they all belong to living species and occur from Alaska to Mexico.

LAND-SHELLS.

Succinea salleana ?, Pfr.
Hyalina (*Conulus*) *chersina*, Say.
Hyalina conspecta, Bland.
Hyalina arborea, Say.
Pupilla fallax, Say.
Vertigo ovata, Say.
Pupa muscorum, Linn.

FRESHWATER-SHELLS.

Bythinella tenuipes, Couper.
Limnæa desidosa ? Say.
Pisidium virginicum ? Bourg.
Planorbis parvus, Say.
Anodonta ? (in small fragments).

CRUSTACEAN CASES.

Cypris.

Near Cañon City, Col., I saw detached bones, apparently of the Bison, which were obtained at a depth of twenty feet in adobe. Other similar finds are reported in the same region, but the bones obtained have not been preserved. In one instance, near the same locality, a tooth of an Elephant was obtained at a depth of forty feet in the adobe deposit. These bones are always detached, and are true fossils belonging to the deposit in which they occur.

The only marine shells found in the adobe are fossils that have been derived from older rocks. An instance of this came under my notice near Cañon City, where fragments of an *Inoceramus* were found in this deposit, which could be readily traced to Cretaceous outcrops near at hand. These fossils should be considered merely as pebbles so far as they relate to the character and origin of the adobe.

Mode of Formation.—That adobe is a subaërial deposit derived from the waste of surrounding mountain slopes, does not seem open to question. Its accumulation is now in process and may be studied in all its details at thousands of localities; the most instructive being the drainless and lakeless valleys of Utah, Nevada and neighbouring areas. The action of ephemeral streams and of the general surface wash in transporting debris from the uplands to the valleys may be observed in such basins at any time when rain falls. The thousands of little streams and rills, born in the hills of the Arid Region from the waters of passing showers, flow rapidly down the steep slopes, loaded with coarse sediment and turbid with fine yellow silt. On leaving the mouths of the rocky gorges, and entering one or more of the channels that lead from them down the alluvial slopes, the coarse material is deposited, and when the showers are transient, the water disappears by evaporation and by percolation through the material of the alluvial cones. During this process fine silt is deposited in the interspaces of the alluvial cones, and serves to make them more and more impervious. When the rain is copious, the streams may continue to the plain where the waters spread out in sheets among the desert shrubs, and deposit their silt.

The particles of silt deposited by the ephemeral streams absorb the precipitates which are thrown down when the evaporation of

the water that transported them takes place. During the long hot summers the water absorbed by the material filling enclosed basins is drawn to the surface by capillary attraction and evaporated. In this manner additional mineral matter is precipitated among the sedimentary deposits. It is evident, therefore, that the fine yellow earths filling enclosed basins owe their accumulation to both mechanical transportation and chemical precipitation.

It may be suggested in this connection that the coherency of adobe, which enables it to stand in vertical escarpments for a long series of years, may be due to the partial cementation of its particles by the precipitation of mineral matter, principally calcium carbonate, among them.

An examination of the fine silt in alluvial cones shows that it is identical with the silt forming the plains in the lower portions of the valleys in which they occur, except that it is not so evenly assorted, and in general is coarser. In both situations it is usually light yellow in colour, seemingly without reference to the character of the rocks from which it was derived. In addition to the material swept into the enclosed basins by ephemeral streams, there is another source of supply through aërial transportation. Dust is blown from the mountains overlooking the areas of accumulation and from neighbouring valleys, but the amount thus contributed is very small in comparison with the vast quantities of both coarse and fine material transported by water in the manner described above. This subject is again referred to on page 349.

The fine dust blown into the air by volcanoes has also contributed to the filling of the valleys of the Arid Region. The total quantity of fine particles thus deposited must be very great, but it has only been observed near recent volcanoes in the neighbourhood of Mono Lake, Cal., and in Southern Utah. Interstratified with lacustrine sediments in the basin of Lake Lahontan[1] there are deposits of white volcanic dust aggregating a thickness of perhaps six or eight feet, which was derived from the Mono craters two hundred miles away. This indicates that very many of the drainless valleys of Nevada and California must have received important contributions from the same source.

Relation of Adobe to Playa Deposits.—When an inclosed basin receives sufficient precipitation to form a lake, a portion of the fine debris swept down from neighbouring hills will be carried into it and deposited. In the Arid Region transient water bodies of this nature termed playa lakes are formed during every storm. These lakes are of all sizes up to hundreds of square miles in area, but are always extremely shallow, a depth of more than a few inches being rare. They usually disappear as quickly as they came, when the storms which supplied them pass away. On evaporating they leave a smooth plain or playa of light yellow mud, which is of almost impalpable fineness, and shows only very obscure, if any, lines of stratification. The last statement is based on a number of excavations which have been made in such deposits to a depth of six or eight

[1] Monograph No. 11, U.S. Geol. Surv., 1885, p. 146.

feet; but, as natural sections are wanting, the thickness of these deposits as well as their internal structure is not well known.

The lack of stratification in playa deposits may perhaps be due to the peculiar conditions under which they accumulate. The material composing them is fine throughout, but the waters continue turbid so long as they remain unevaporated, and the last addition made to the filling of the basin, in part a chemical precipitate, is of exceeding fineness. When the basins are refilled, this mud is quickly saturated, and may be again taken in suspension and in part redissolved. The deposits of various rainy periods may in this way be mingled so intimately that no lines of stratification would appear.

Playa lakes are sometimes alkaline and saline, and on evaporating deposit salts of various kinds. Commonly, however, especially in the smaller basins, no salt appears at the surface, but the playas present a smooth, even expanse of cream-coloured mud, which becomes hard and divided into a net-work of shrinkage cracks when it dries.

The fine sediment carried down the sides of an inclosed basin holding a playa lake is deposited in part before reaching the lake, and in part, as we have seen, in the lake itself. In both instances the accumulation is a yellow, finely divided earth, practically without stratification. In both instances the fine silt may have worn or angular pebbles and stones mingled with it, but in large valleys the accumulations, whether subaërial or subaqueous, are entirely of homogeneous yellow earth. The only marked difference in these deposits is that the playa are much more saline than the subaërial earths. The sediments of playa lakes are sometimes obscurely vesicular, as if small gas bubbles had been formed in them. In subaërial deposits this has not been observed. The subaërial deposits, on the other hand, are traversed, at least in a number of instances, by small vertical tubes that branch downward; in the playa deposits these are not present.

Relation to Stream Deposits.—Wherever the streams of the Arid Region overflow during high water and submerge their flood plains, a fine deposit is thrown down which in many instances is to all appearance identical with the adobe formed in drainless valleys.

The deposit made by a stream in its immediate channel, at least in the vicinity of mountains, is coarse, and is frequently composed of well-worn boulders and gravel. As the stream sways from side to side of its general course during a succession of years, a sheet of gravel is spread out as a flooring over an entire valley. The material deposited on the flood-plain however, and superimposed on the gravelly stream-bed previously laid down, is usually a fine silt, which in many instances does not show lines of stratification.

Along the streams of the Arid Region the flood plain deposits are frequently composed of fine, grey adobe, which breaks in vertical walls when undermined, and is without stratification. In some instances it is penetrated by vertical tubes apparently made by rootlets. In all these characteristics the stream deposit agrees with the subaërial deposit.

That the flood-plain deposits of an arid country should be of the same character as the adobe deposited on gentle slopes and in inclosed valleys by ephemeral streams, is not surprising, since the process in each instance is essentially the same and the material handled is identical. The ephemeral streams spread out their waters on reaching gentle slopes, and deposit their sediment quietly among the scanty desert vegetation. In the case of perennial streams which overflow their banks the process is similar, that is, they form sheets of comparatively still water along their borders, and deposit silt about the vegetation which obstructs their flow. In both instances it is to be expected that casts of the roots of plants would remain in the soil. Evaporation takes place in both instances, thus contributing precipitated mineral matter to the deposits, but occurs most rapidly in the case of the ephemeral streams.

In flood-plain deposits the shells of the freshwater molluscs occur, while land-shells may or may not be present. In the deposits of ephemeral streams the shells of land molluscs predominate, not to the exclusion of freshwater-shells, however, since the deposits are laid down by streams which in their upper course may survive throughout the summer and be inhabited by molluscs. The bones of land-mammals may be buried during either mode of accumulation.

The geological interest of adobe and allied deposits centres not only in the manner in which they are formed, but also in their extent and depth when accumulated under favourable conditions.

It is evident that the subaërial filling of an inclosed basin with fine material might continue in the manner described, until the depression was filled or the source of supply exhausted, so long as the climate conditions remain favourable. A decrease in precipitation would retard the filling or perhaps check it altogether, while an increase would favour the extension of playa lakes, or transform them into permanent water bodies. Should the increase be sufficient, the permanent lakes would overflow and cut down their channels of discharge until their basins were drained to the bottom. It appears, therefore, that the maximum thickness which subaërial deposits may attain in an arid region is very great, especially in the case of fault valleys, which may have their borders raised at the same time that their bottoms are being filled.

The thickness which playa lake deposits may attain is also very great; for, like the subaërial deposits just considered, they depend for their accumulation, the supply continuing, on a combination of climatic and topographic conditions which may remain favourable for a long period of time.

Of the three methods described above, by which fine silt deposits may be accumulated in arid regions, the least important in a geological point of view is the one dependent on the overflow of streams. In the formation of flood-plains the conditions favouring accumulation depend not only on climatic and topographic conditions, but more definitely than in the other instances on the supply of suitable material. The supply of sediment not only determines whether a stream shall deposit or not, but whether the

deposits once laid down shall remain. In the formation of adobe and playa deposits, however, there is substantially no waste.

While adobe and playa deposits depend on aridity of climate for their formation, the flood-plain deposits are not so limited, but may go on apparently with the same results in an arid as in a humid climate, provided a periodic variation in the volume of the streams takes place, sufficient to cause them to overflow their banks during the flood stage. There seems to be no reason to suppose that the character of flood-plain deposits in arid and in humid regions should be distinct, unless it be that the fine material washed into streams in dry countries is largely supplied from subaërial deposits which have already been assorted, and perhaps have a different chemical character from the surface debris of humid regions.

It is beyond the scope of the present paper to discuss the processes by which flood-plain deposits are formed, especially as accumulations of this character are comparatively inconspicuous in the Arid Region, and also because the constructive power of streams has been extensively studied elsewhere.

The accumulation of adobe and of eolian and volcanic dust in the central portions of the valleys of the Arid Region, together with the formation of talus slopes and alluvial cones about their borders, promotes the levelling of the hills and the filling of the intervening depressions. The tendency of this twofold process is to reduce the country to a plain, but not to bring it to sea-level. An exception here exists to the nearly universal law of base-level erosion, an exception, however, that is transient when considered in the way that geologists are forced to reckon time. A long continuation of existing climatic conditions, together with an absence of orographic movements, in the Great Basin portion of the Arid Region, would result in the formation of a broad high-level plain with rocky crests projecting here and there to mark the sites of buried mountain-ranges. A change to more humid conditions after this process was far advanced would initiate drainage systems which would make rapid changes in the configuration of the region. One of the first results of an increased rainfall would be the cutting of deep cañons, especially in the unconsolidated adobe and playa deposits, thus exhibiting sections of these peculiar formations and revealing their great thickness.

In connection with a description of the occurrence of adobe it is proper to state that nothing similar to the red soils formed by the residual clays of the South Atlantic States, or the *red earth* of Bermuda and the West Indies, or the *terra rossa* of Southern Europe, or the *laterite* of India, is to be seen anywhere in the Arid Region. Rock disintegration is there active, but rock decomposition is retarded. The absence of residual clays from the comparatively rainless portion of this country is of interest as tending to show that such deposits are formed in humid and not in arid countries.[1]

[1] The subaërial deposits of humid regions have been discussed at some length by the present writer in Bulletin No. 52 of the U.S. Geological Survey (1889), to which this paper may be considered as a supplement.

II.—Comparison of the Adobe with the Loess of China.

It is of interest to compare the adobe of the Arid Region with similar accumulations elsewhere, and especially with the loess of China, which has been very fully described by F. Von Richthofen.[1]

In China there are many basins comparable with those in the more arid portion of the United States, which are deeply filled with a yellow marly-clay of impalpable fineness termed Loess, which is without stratification, breaks most readily in a vertical direction, and stands in perpendicular escarpments for many years. It is traversed by vertical tubes of small dimensions which bifurcate downward; is charged with land-shells, and contains the bones of land-mammals. In all of these particulars the loess of China agrees with the adobe of the Arid Region. The loess is described as being uniformly yellow in colour, and, as we have previously stated, this is the characteristic colour of the vast subaërial deposit of the Arid Region, except when charged with organic matter.

In China certain peculiar concretions occur in the loess, figures of which are given by Richthofen;[2] these, so far as known, are not represented in the adobe.

A portion of the loess of China, termed "lake loess," has been described as being a stratified deposit formed in saline lakes. These beds are practically identical with the playa deposits of the Arid Region, except that a more marked stratification has been observed in them. In each country these deposits are composed of fine, light yellow earth, more or less saline, and sometimes carry salts of various kinds in sufficient quantities to be of commercial value.

The loess of China has been shown by Richthofen to have a thickness of fully 2000–2500 feet. There is a lack of accurate data by which to determine the thickness of the similar deposits in America, but observations based on the contours of valleys and on the records of the few wells that have been bored, indicate, as already stated, that in many instances it is fully as thick as the loess.

In China the peculiar property of the loess, which admits of its standing in vertical escarpments, is utilized by the inhabitants, who excavate houses in the faces of the bluffs. In America the same property in the adobe admits of the formation of sun-dried bricks, which have been used in the construction of thousands of houses, and in many instances of entire towns. In each country the deposits mentioned form exceedingly rich agricultural lands.

The loess is described as being porous, so that rain falling on it is rapidly absorbed. This property is shared in part by the adobe, but is not a characteristic feature of the deposit in general. On the alluvial cones and in the higher portions of the adobe-filled basins of the Arid Region, the rain-water rapidly disappears by percolation, but in other instances, and especially in the playas, the earth is extremely impervious. Only a foot or two beneath the playa lakes

[1] China, Berlin, 1877, vol. i. pp. 56-189. See also abstract in Am. Jour. Sci. 3rd series, 1877, vol. xiv. pp. 487–491.

[2] China, vol. i. p. 58.

the yellow earth is always dry and powdery. These lakes are frequently called "sinks," as the "sink of the Carson River" for example; but a more complete misnomer could scarcely be cited, as the water escapes from them solely by evaporation.

There is one remarkable peculiarity in which the loess region of China differs from the Arid Region, that is, it has been deeply dissected by stream erosion, so that the vast thickness of its superficial deposits is fully exposed. In this country the valleys of the Arid Region are still being filled, and dissection has not commenced. In China a recent climatic change, perhaps very moderate in its character, seems to have occurred, which has allowed of the formation of streams in a previously drainless region, and the streams have sunk their channels in the loess in the wonderful manner described by travellers.

The similarity between the loess of China and the adobe of America is such as to warrant the conclusion that they were deposited under essentially the same conditions. That they are both mainly subaërial deposits, it seems to me, must be acknowledged by every one who is familiar with the geological processes now active in arid regions.

Richthofen[1] refers the origin of the loess of China to three processes: "The first is rain water, which flows down from the upper to the lower parts, and washes away the solids which have become loosened by the decomposition of the rocks of neighbouring mountains. The second is the wind, whose extraordinary aid in accumulating dust-like divided solid material, one has frequent opportunity to notice in the regions occupied by the loess. The third agent lies in the mineral ingredients, which the roots of grasses, by the diffusion of mineral fluids drawn up from below, assimilate, and on their decay leave behind. All these finely divided ingredients are held fast by the vegetable covering, and thence afterwards carried away only in small quantities by the wind."

The second and third of these processes are held by Richthofen to be most important; and of these two by far the greater prominence is given to the second, that is, to the action of the wind in transporting dust. My own studies in the arid portions of this country failed to sustain this explanation, but lead me to refer the accumulation of both the coarse and the fine deposits now accumulating in the drainless valleys of that region to the first hypothesis mentioned above; that is, to the transportation and deposition of fine material by ephemeral streams.

That eolian transportation is an element in the process by which inclosed valleys are filled with fine debris must be acknowledged; but that it is the principal, or even an important element, does not appear to be warranted by a study of the processes by which such deposits are now being formed.

Richthofen has shown so clearly that the loess of China was not accumulated in freshwater lakes or in the ocean, that the hypotheses

[1] China, vol. i. p. 78.

advanced by various writers who have referred its origin to ordinary sedimentation need not be considered farther.

In reference to the accumulation of loess through the vital action of vegetation as advocated by Richthofen, it is perhaps sufficient to suggest, as has been done by T. W. Kingsmill,[1] "that plants could furnish to the mineral accumulations only what they took from it, and hence could add nothing." Apparently no exception can be taken to this argument, unless it be that plants may add carbon derived from the carbonic acid of the atmosphere, to the soils in which they grow.

The similarity between the loess of China and the adobe of the Arid Region is so close that they might properly be designated by the same name; but, as confusion has apparently already arisen from the too general use of the former name, it has been thought best to use a new term instead.

Washington, D.C., Nov. 27, 1888.

III.—Glaciation of High Points in the Southern Interior of British Columbia.

By George M. Dawson, D.Sc., F.G.S.;
Assistant-Director of the Geological Survey of Canada.

In an article published in the Geological Magazine for August, 1888, an outline was presented of some facts resulting from recent investigations on the glaciation of British Columbia and adjacent regions, bearing more particularly on the flow of ice in a northerly direction brought to light by explorations in the Yukon district, but touching also on the south-eastern extension of the great western glacier-mass of the continent, which I have proposed to name the Cordilleran glacier. Field-work carried out by me during the summer of 1888 has resulted in the accumulation of many new facts relating to the southern part of the area, which was at one time covered by the Cordilleran glacier, from which it would appear that it may ultimately be possible not only to trace the various stages in the recession of the main front of the great confluent glacier beneath which the interior or plateau region of British Columbia was buried, but even to follow the later stages of its decline as it became broken up into numerous local glaciers confined to the valleys of the several mountain ranges which limit the plateau.

As, however, work is to be continued in the same southern part of British Columbia during the present summer, it is not at present intended to discuss these general features, but merely to call attention to the noteworthy heights at which glaciation has now been found to occur on some of the higher parts of the Interior Plateau and its mountains, and to the great mass thereby indicated for the southern part of the Cordilleran glacier.

The highest point on which I had previously noted the marks of

[1] Quart. Journ. Geol. Soc. London, 1878, vol. xxvii. p. 380.

glacier ice in this region was Iron Mountain, at the junction of the Nicola and Coldwater rivers, the summit of which is 3500 feet above the neighbouring river valleys, or 5280 feet above the sea.[1] Evidence of the same kind—all implying the movement of a great glacier-mass entirely independent of the local features of the country—has now been discovered on several still higher points, the most elevated being Tod Mountain, situated 25 miles north-east of Kamloops, and rising 7200 feet above the sea. The actual summit of this mountain is, however, but lightly glaciated, and in this circumstance and the apparent influence which local irregularities of rock-surface have had upon the direction of striation, evidence seems to be afforded that the summit was never deeply covered by the great glacier. This conclusion is further borne out by the fact that a few hundred feet only lower down the same mountain, the glaciation is much stronger, and fluted rock-surfaces and other easily recognized marks of heavy glacier ice are observed. Tod Mountain is the culminating point of a region surrounded on three sides by the wide and important valleys of the North and South Thompson Rivers and Adams Lake, the nearest points comparable in elevation to it being in the Gold Range, at a distance of over 25 miles in a north-easterly direction, or nearly at right angles to the direction of the glaciation. There can be no question as to the fact that the glaciation met with at this place is due to the general or Cordilleran glacier, and it is thus evident that at one period the glacier ice must have attained a thickness of about 6000 feet in the valleys above named, while it covered even the higher portions of the irregular plateau of this part of the interior of British Columbia to a depth of at least 2000 to 3000 feet. When it is taken into consideration that evidence has already been obtained of the south-easterly motion of this part of the Cordilleran glacier for a distance of at least 300 miles to the north-west of Tod Mountain, it is apparent that the mass of *névé-ice* accumulated over the country north of the 55th parallel of latitude from which the southerly- and northerly-flowing extensions of the great glacier were fed must have been enormous.

As previously stated by me, the condition of this part of the Cordilleran region, at the period of its maximum glaciation, must have been clearly analogous to that of Greenland at the present day, save that in the case of British Columbia it has been impossible for any large proportion of the ice to escape to the eastward or to the westward because of the bordering mountain ranges.

Some of the principal new localities at which distinct evidence of the passage of the Cordilleran glacier over the southern part of British Columbia were observed during the summer of 1888, with the approximate position and height of each and the direction of motion indicated, are given below. The variation in direction found in comparing even the highest stations is generally explicable on consideration of the influence of adjacent important orographic features. A number of observations made at points somewhat lower than these here quoted show, as might be anticipated, an increasing

[1] Quart. Journ. Geol. Soc. vol. xxxiv. p. 272.

degree of influence of the same kind dependent on the subordinate relief of the country passed over.

Place.	Approximate Latitude.	Approximate Longitude.	Height in feet.	Direction (true bearings).
High Plateau between N. Thompson and Bonaparte Rivers.	51° 6′	120° 56′	4340	S 20° E
,, ,, ,,	51° 4′	120° 45′	5100	S 34° E
,, ,, ,,	51° 9′	120° 26′	5430	S 37° E
,, ,, ,,	50° 59′	120° 25′	5440	S 35° E
Tod Mountain	50° 56′	119° 55′	7200	S 44° E
High Plateau between Adams and Shuswap Lakes. ...	51° 1′	119° 41′	6100	S 27° E
Cinder Mountain.	50° 34′	121° 8′	5180	S 50° E
Loadstone Peak	49° 25′	120° 50′	6280	S 15° E

IV.—Notes on New and other Dinosaurian Remains.

By R. Lydekker, B.A., F.G.S., F.Z.S., etc.

In the present communication I call attention to a Reptilian vertebra which does not appear to have received the notice it deserves, and also give a preliminary diagnosis of certain forms which I hope to describe more fully later on.

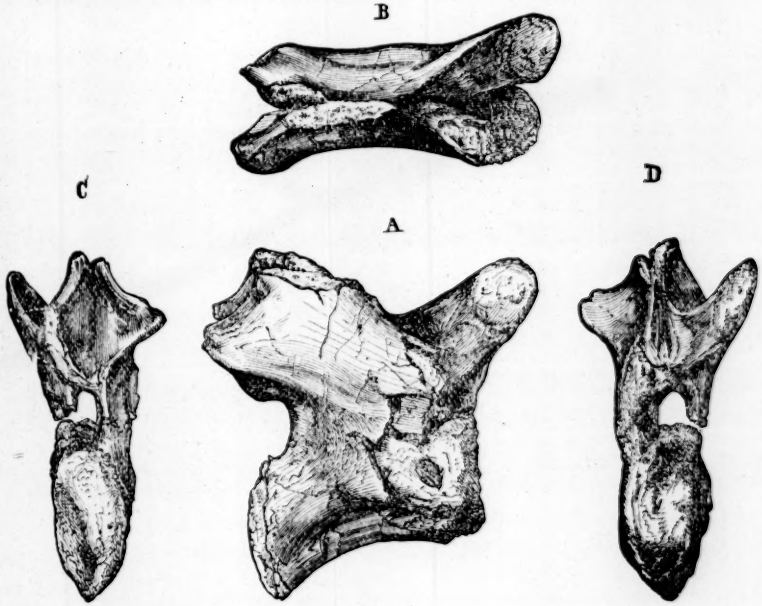
1. Arctosaurus Osborni, Adams.

In the year 1875 the late Professor Leith Adams described and figured in the "Proceedings of the Royal Irish Academy" (ser. 2, vol. ii. p. 177) an imperfect Saurian vertebra which had been obtained many years previously from Arctic America during the voyage of Captain Sherrard Osborn, which is now preserved in the Museum of Science and Art, Dublin. The specimen was obtained from beds of unknown but doubtless Mesozoic age at Rendezvous Mountain, which is situated at the north end of Bathurst Island in 70° 36′ north latitude.

By the courtesy of Prof. V. Ball, Director of the Science and Art Museum, Dublin, I have recently had an opportunity of examining this interesting specimen, of which, by permission of the Royal Irish Academy, I am able to reproduce the original figure. In his original description of the specimen, which has suffered by lateral crushing and is otherwise imperfect, Prof. Adams considered that it indicated a cervical vertebra, which had lost the neural spine, the costal articulations, and the right prezygapophysis. And he then proceeds to give his reasons for regarding it as more nearly allied to Lizards than any other reptiles.

My own observations confirm the conclusion that this vertebra belongs to the cervical region; but it appears that its affinities are certainly Dinosaurian. The centrum is compressed and amphicœlous, with a sharp hæmal carina; and it is evident that there were free cervical ribs and a well-developed neural spine. The highly curved ventral profile and the length of the centrum indicate that the

owner of this vertebra had an arched and comparatively elongated neck; the whole *facies* of the specimen being essentially Dinosaurian. Moreover, in the deep median incisions between the pre- and post-zygapophyses the specimen resembles the cervicals of many of the Theropoda; while a longitudinal fissure on the right side of the centrum is highly suggestive of the crushing in of an internal cavity. That the specimen does not belong to the *Cœluridæ* is quite clear; and I am inclined to regard it as indicating a Dinosaur more or less closely allied to the *Anchisauridæ*, although, in the absence of figures of the typical American forms, it is at present impossible to institute any exact comparison. The especial interest of this specimen is the evidence which it affords as to the path by which the generic types of Dinosaurs common to the old and new worlds may have passed from the one hemisphere to the other.



Arctosaurus Osborni. Right lateral (*A*), neural (*B*), posterior (*C*), and anterior (*D*) aspects of an imperfect cervical vertebra; from Bathurst Island. Nat. size. (*From the Proc. R. Irish Academy.*)

2. Orinosaurus capensis, n. sp.

In describing certain Dinosaurian remains from the Karoo System of the Cape in 1867, Prof. Huxley (Quart. Journ. Geol Soc. vol. xxiii. p. 5) applied the name *Orosaurus* to a large bone which he regarded as the distal extremity of a femur, and considered to be generically distinct from the other specimens described in the same paper under the name of *Euscelesaurus*. This bone has been recently presented by its describer to the British Museum (No. R. 1626), and after careful examination I am convinced that it is really the

proximal extremity of a left tibia. It agrees very closely, both in size and characters, with the tibia of *Iguanodon Mantelli*, but appears to have been solid throughout. The great expansion of the head and cnemial crest distinguishes it from the tibia of *Eusclesaurus*, which appears to have had a bony union with the fibula, as in *Stegosaurus*, and it therefore appears that the generic distinctness of *Orosaurus* is justified. Unfortunately, however, this term is preoccupied by the more correctly formed *Oreosaurus*, Peters,[1] and I accordingly propose to replace it by the name *Orinosaurus*.[2] Since, moreover, no specific name was proposed by Prof. Huxley for this Dinosaur, I would suggest that it should be known as *O. capensis*.

If I am right in regarding this tibia as solid throughout, the specimen is of considerable interest as apparently showing a connection between the *Stegosauridæ* and *Iguanodontidæ*, and thereby serving to confirm Dr. Baur in his conclusion that these two families should be included in a single suborder.

3. Iguanodon Fittoni, n. sp.

Among a series of specimens from the Wadhurst Clay near Hastings, recently collected by Mr. C. Dawson, F.G.S., for the British Museum, are an apparently associated left ilium, part of a pubis, and the imperfect sacrum (B.M. No. R. 1635), which appear to indicate a distinct species. The specimens were obtained at the village of Shornden, and although the sacrum was found at a distance of some fifty yards from the ilium, Mr. Dawson has no doubt that both specimens belonged to the same individual.

The ilium, which I take as the type of this form, indicates a somewhat smaller animal than the ilium from a somewhat lower horizon which forms one of the types of *I. Dawsoni*.[3] Moreover, it differs from that ilium in that the preacetabular process merely forms a thin vertical plate, and entirely wants the horizontal inner extension found on the lower border of the latter. Again, while in *I. Dawsoni* the postacetabular portion forms a deep plate with a rounded termination, the corresponding portion of the present specimen has its lateral surface terminating in a point, while the inferior border is bent inwardly to form a shelf-like projection on that side. The portion of the ilium immediately above the acetabulum is relatively deeper, and the acetabulum itself less well defined than in *I. Dawsoni*. The associated sacrum has laterally-compressed and anchylosed vertebræ like those of *I. Mantelli*, from which species the present form is at once distinguished by the greater height of the ilium and the inflection of the lower border of the postacetabular portion. The only other named form to which this specimen could possibly belong is *Sphenospondylus gracilis* of the Upper Wealden, but the ilium appears to be proportionately much too large for the vertebræ, and the sacrum is different from the one which I have suggested may belong to that genus.

I propose to designate this apparently new form as *I. Fittoni* in

[1] Abh. Ak. Berlin, 1862, p. 201. [2] From the adjectival ὀρεινὸς.
[3] See 'Cat. Foss. Rept. and Amphib. in Brit. Mus.' pt. i. pp. 197-199.

honour of the late Dr. Fitton, so well known for his labours in connection with the Lower Cretaceous of England. The ilium of this species, so far as its posterior portion is concerned, makes a remarkable approach to the type species of the American *Camptosaurus*, from which, however, this form is widely distinguished by the structure of the sacrum.

4. Iguanodon hollingtoniensis, n.sp.

Specimens from the Wadhurst Clay of Hollington, near Hastings, appear to indicate a third species from these deposits which I propose to distinguish, at least provisionally, as *I. hollingtoniensis*. Some of these remains I have previously referred in the work cited to *I. Dawsoni*, while others I have suggested might belong either to that species or to immature examples of *I. bernissartensis*.

I take as the type the specimens in the British Museum numbered R. 1148[1] together with others belonging to the same individual numbered R. 1629, and also certain vertebræ numbered R. 1632, which are also believed to have belonged to the same individual.

The femur (R. 1148) agrees approximately in size with that of *I. Mantelli*, but is at once distinguished by its curved shaft and pendant inner trochanter, in which respects it resembles the corresponding bone of *Camptosaurus*. It is smaller and of different contour from another femur, which, from the evidence of the associated ilium, belongs to *I. Dawsoni*. The sacral vertebræ (R. 1632) are of the type of those (B.M. No. R. 811) I have previously referred to the latter species,[2] having flattened hæmal surfaces to the centra, which were not anchylosed together. An ilium (No. R. 811*b*) associated with the sacrum and ischia No. R. 811, although very imperfect, shows that the preacetabular process was of the thin type of *I. Fittoni*, and therefore different from that of *I. Dawsoni*, while this ilium is decidedly different from that of *I. Fittoni*. Finally, the dorsal vertebræ associated with Nos. R. 811 (B. M. No. R. 604) and with R. 1148, are smaller and more compressed than those of *I. Dawsoni*.

That the present form is distinct from *I. Mantelli* is shown by the femur; from *I. Dawsoni* it is distinguished by the size of the femur, and of the dorsal vertebræ, as well as by the size and contour of the ilium which is apparently referable to it. The sacral vertebra, No. R. 1632, which is believed to have been associated with the type specimen, distinguishes this species from *I. Fittoni*; this being confirmed by the sacrum No. R. 811, which is now known to have been associated with vertebræ and an ilium which are clearly not referable to *I. Dawsoni*, and still less to *I. Fittoni*.

Iguanodon hollingtoniensis approximates in the structure of its femur, ischia, and sacrum to *Camptosaurus*, but is distinguished by the peculiar pollex of *Iguanodon*, on which account I include it in the latter genus.

I am at present unable to say definitely whether the unnamed imperfect skeleton in the British Museum from Hollington numbered

[1] 'Cat. Rept. etc.,' *op. cit.* p. 217.

[2] *Op. cit.* p. 199.

R. 33[1] belongs to *I. Fittoni* or *I. hollingtoniensis*, although, as I have remarked in the work cited, it is certainly distinct from *I. Mantelli*. I may add that the bone in that skeleton catalogued as a fragment of an ilium proves to be the glenoidal portion of the right coracoid.

V.—The Occurrence of Granite in a Boring at Bletchley.

By A. J. Jukes-Browne, B.A., F.G.S.

In the winter of 1886–7 a boring was made at Bletchley Junction for the London and North-Western Railway Company, and acquired importance from the report that, after passing through the Oxford Clay, it had entered a mass of granitic rock.[2] Probably many readers of this Magazine wondered why no detailed account of the boring was published after this announcement; but the reason was, that when inquiries came to be made, some uncertainty was found to exist as to the position and mode of occurrence of the granitic rock. My attention was recently called to the boring by learning that the water obtained from it was salt. I then obtained all the information I could with regard to the rocks passed through, and think the results are of sufficient importance for publication. The interest naturally centres in the supposed occurrence of granitic rock at a depth of less than 400 feet from the surface, and it seems desirable that the facts with regard to this should be placed on record.

The boring was made by Mr. Ebenezer Timmins, of Runcorn, under the superintendence of Mr. F. W. Webb, the Engineer of the L.N.W.R. Company. The work was personally directed by Mr. Arthur Timmins, to whom I am indebted for the particulars given below; Mr. A. Timmins tells me he had the first handling of all samples which were brought up, and that he took some trouble to ascertain the nature of the rocks through which the boring was carried, making analyses of several of the specimens himself. All this information he has generously placed at my disposal, and the following is his account of the boring.

Old well 148 feet deep. Boring commenced from bottom of well. Level of surface about 260ft. O.D. :—

	Thickness. ft.	in.	Depth. ft.	in.
1. Depth of old well	—		148	0
2. Blue limestone	8	0	156	0
3. Blue clay	9	0	165	0
4. Black shale	1	0	166	0
5. Yellow clay	2	6	168	6
6. Brown clay	17	6	186	0
7. Blue limestone	1	0	187	0
8. Brown clay	5	0	192	0
9. Blue limestone	12	0	204	0
10. Blue clay	8	0	212	0
11. Blue limestone	5	9	217	9
12. Blue clay	6	3	224	0
13. Blue limestone	1	0	225	0

[1] *Op. cit.* p. 226.

[2] See Prof. Hull's letter, Geol. Mag. Dec. III. Vol. IV. p. 139 (1887).

	ft.	in.	ft.	in.
14. Blue clay with septaria	36	0	261	0
15. Blue limestone	1	0	262	0
16. Blue clay with septaria	40	0	302	0
17. Blue limestone	3	6	305	6
18. Blue clay	4	6	310	0
19. Blue limestone	1	0	311	0
20. Blue clay	45	0	356	0
21. Indurated bluish limestone	22	5	378	5
22. Granitic rock	21	7	400	0
23. Clay	1	0	401	0
24. Granitic rock	6	2	407	2
25. Clay	2	10	410	0

The following observations are chiefly by Mr. A. Timmins, with a few remarks of my own on the samples which he sent me, and which are now in the possession of Prof. A. H. Green at Oxford.

No. 3 was a very hard blue clay.

No. 4. A bituminous shale containing iron pyrites.

No. 9. Sample preserved, a dark grey limestone, with well-marked oolitic structure, several Echinoderm spines, and some shell fragments.

No. 11. Samples preserved probably from this bed are of a grey shelly and partially oolitic limestone.

No. 13. Sample preserved from 224 feet, a light grey crystalline limestone, very hard, with glistening surfaces of calcite, possibly parts of Echinoderm tests and spines.

No. 14. A very hard clay full of septaria and pyrites.

No. 16. The same as No. 14. Samples of the septaria preserved and analysis made by Mr. Timmins with following result:—

Insoluble siliceous matter	9·800
FeO (originally $FeCO_3$)	34·418
Fe_2O_3, iron peroxide	33·423
Alumina	3·392
Calcium carbonate	17·050
Magnesium carbonate	2·291
	100·374

Nos. 18, 19, and 20. These beds were full of fossils, but all the larger specimens were broken up by the chisels; those preserved are chiefly fragments of the stems and arms of small Crinoids, with several pieces of small Belemnites and fragments of bivalve shells. They are just such fossils as would occur near the base of the Oxford Clay.

No. 21. No sample preserved, but described by Mr. Timmins as a "very hard limestone." At about 360 feet it contained hard nodules or boulders of stone of a dark buff colour and having cracks filled up with calcite; they were calcareous and ferruginous, with only 15 per cent. of insoluble matter. A sample from 370 feet had the following composition:—

Insoluble matter	53·48
Oxide of iron and alumina	20·40
Calcium carbonate	26·06
	99·94

My colleague, Mr. A. G. Cameron, has sent me a piece of Kellaway rock, from Kempton, near Bedford, which is a very hard, compact,

greyish-brown ferruginous and siliceous limestone; the general character of this rock is such as to suggest a chemical composition similar to that of the above analysis of the "indurated limestone" in the boring, and it has cracks filled with calcite.

Mr. Timmins says that from the foreman borer's account it would appear that this bed gradually got harder and harder till they came on to the "granitic rock" at 378′ 5″, and that the depth of colour also increased to a rusty brown.

No. 22. The following are Mr. Timmins' notes on this rock:—"The boring of this bed proved a very tedious operation, averaging about five inches a day, and owing to this incessant grinding of débris, large particles of rock were not to be expected: what samples there are were found after sifting the whole débris through a sieve of 1225 meshes to the square inch. The analysis of a bulked sample between 378′ 5″ and 390 feet is as follows:

Insoluble matter	80·106
Oxide of iron and alumina	11·514
Calcium carbonate	3·838
Magnesium carbonate	·640
Alkalies, etc., not determined	3·902
	100·000

Before analyzing this sample, all particles of steel and iron from the boring tools and casing tubes were extracted as well as possible with a magnet; but it is possible that some of the 11½ per cent. of iron is derived from the mechanical appliances in use."

Samples of this material are preserved in bottles, the larger fragments are undoubtedly pieces of a granitic rock; the finer material which has passed through the sieve is of a brownish colour, and has the appearance of a pounded, fine-grained ferruginous sandstone. More will be said of this in the sequel.

Bed 24 was similar to bed 22, but was not so hard and compact, so that more rapid progress was made through it.

Beds 23 and 25 were clays with a blue colour when first brought into daylight, but after a few days in the air the colour began to fade, and through gradual gradations it arrived at a light brownish tint; this is probably due to the oxidation of the iron. An analysis of one of these clays gave the following results:

Insoluble siliceous matter	79·807
Oxides of iron and alumina	13·778
Calcium carbonate	2·997
Magnesium carbonate	1·718
	98·300

Mr. Timmins remarks that it had somewhat the aspect and composition of a fire-clay. As the sample sent to me had rather a powdery felspathic look about it, I forwarded it to Prof. Bonney, who reported that it appeared to be an ordinary clay, "such as might well occur in the Jurassic series"; and that it was not a decomposed igneous rock or felspar rolled *in situ*, and had certainly not been baked by contact with igneous rock, as it must have been if the beds of "*granitic rock*" were intrusive sheets.

To complete the record of the boring, it may here be mentioned that water was found at the depth of 390 feet 9 inches in the first bed of "*granitic rock*," and again in the lowest clay at 410 feet, or more probably from a bed immediately underlying this clay, but not pierced. In both cases the water was very salt and unfit for use, so that the boring was abandoned and a coffee-house is now built over the site.

We may now revert to the so-called "granitic rock." It has already been stated that fragments of such a rock do certainly occur among the samples, and there seems no reason to doubt that these fragments were brought up from the depths named. As evidence on this point I quote a letter from Mr. A. Timmins to Mr. Cameron, dated November 19, 1886:—"I enclose a sample of the strata from present depth (390 ft.) . . . I make it out as hornblendic granite, and have had suspicions for some time. A few weeks ago my father brought home a piece of stone similar to the sample, and said that he was told by the foreman that it had come up the boring. Ever since I have sieved the samples sent to me, and Saturday was the first time, since that above mentioned, that I was able to get any larger pieces. My suspicions were at once confirmed, and I make out that we have bored through 10 feet of this granitic rock." With this evidence we may I think take it for granted that pieces of a granitic rock did come up from the depths stated in the account of the boring.

Next as to the nature of the rock: two small fragments were sent to Prof. Bonney, who was kind enough to examine them and reported as follows: "The fragments which you have sent me are of a rock closely allied to granite. As far as I can see with a strong lens they are likely to belong to the microgranulite of Fouqué and Lévy—that is, a rock with felspar quartz and mica or hornblende (probably the latter in this case) in a sort of fine mosaic; the individual grains not being very definite in form unless showing a micrographic structure. It is not a *true* granite, and yet it is rather too crystalline for a normal quartz-felsite . . . I never saw one like it among the Midland Palæozoics, but it has a general resemblance to the rocks of the Narborough district." There is no proof however that the whole of the thickness given to "granitic rock" in Mr. Timmins' account of the boring consisted of the rock above described; there is indeed strong evidence for the belief that it did not. In the first place I am informed by Mr. Cameron that he went over to Bletchley at the time they were boring through this rock, and selected small samples out of the foreman's box from depths of 391 feet and 393 to 396 feet. These he has kindly sent to me, pointing out that they are simply sandstones, without any trace of granitic fragments or minerals. The first is a light-coloured and fine-grained sandstone composed of small quartz grains with ferruginous staining; the second is a dark brown ferruginous sandstone. Both are such rocks as occur in the Kellaways Beds at the base of the Oxford Clay, and the only way of reconciling their existence with the recorded occurrence of granitic rock at about the same depth

is to suppose that boulders and blocks of the latter rock are here imbedded in the Kellaways sandstone.

This explanation would necessitate our assigning a thickness of more than fifty feet to the Kellaways Beds, which is more than usual, but Mr. H. B. Woodward tells me that these beds vary considerably in thickness, and that there would be nothing surprising in their having a depth of 50 feet. We might indeed expect them to be thicker than usual at a locality where they included large blocks of a foreign rock. On this supposition, moreover, the occurrence of an ordinary clay at the bottom of the boring is naturally accounted for; whereas if the material above were assumed to be a massive igneous rock, its presence would be anomalous and very difficult to explain.

It has already been mentioned that springs of saline water were found at depths of 390 feet and 410 feet. Mr. A. Timmins has kindly furnished me with analyses of these waters, and they happen to supply further evidence that the beds from which they issue belong to the Kellaways group. The analyses show 340 grs. and 392 grs. of solid matter in the gallon, the following being the principal ingredients:

	Highest Spring.	Lowest Spring.
Combined chlorine	75·00	91·40
Sulphuric anhydride	108·08	123·24
Calcium oxide	20·02	9·98
Magnesium oxide	4·89	4·37

Residue principally soda.

These proportions are equivalent to about 123 grains of sodium chloride in the highest water, and 150 grs. in the lowest, with 162 grs. of sodium sulphate in the first, and 185 grs. in the second.

My attention has been called to a Report on Bedfordshire well-waters by Dr. C. E. Prior to the Rural Sanitary Authority of the Bedford District (1888), in which mention is made of a band of "saliferous rock" which appears to extend with the Oxford Clay formation from the northern border of the parish of Kempton, across Wootton, and some way into Stanton." He gives partial analyses of some of the well-waters which derive their supply from this rock, and the results show a remarkable correspondence with the Bletchley well-water. The amounts of total solid matter in solution vary from 188 grs. to 250 grs. per gallon. Chlorine is present in all of them, varying in amount from 38 grs. to 92 grs. per gallon. Sulphuric acid is present in several and sulphurous acid in one. Thus at Lower Shelton Marston, which is not many miles north-east of Bletchley, a well-water contained 209·8 grs. of solids per gallon, 72·1 being chlorine and 47·8 grs. being sulphuric anhydride. Dr. Prior comments on the very large quantity of sodium chloride which these waters appear to contain.

There can be little doubt that the saliferous rock of Dr. Prior is one of the beds in the Kellaways group, for all the places he mentions are situate on the lower part of the Oxford Clay.

To sum up, the information available with regard to the boring at

Bletchley points to the conclusion that the Kellaways beds are there thicker than usual, that they include blocks of a peculiar kind of granitic rock, and yield a saline water which contains large quantities of sodium chloride and sodium sulphate.

The occurrence of blocks of microgranulite naturally suggests the possible proximity of some portion of the eastern Palæozoic land. It is generally conceded that the floor of Palæozoic rocks which underlies the eastern counties formed part of a land area during the greater part of the Jurassic period, and indications of the neighbourhood of land are especially abundant in the Great Oolite group which underlies the Oxford Clay. How far the Oxford Clay sea encroached on this land area we do not know, but at the time of the Kellaways Rock the shore is not likely to have receded far from the line which it occupied in Great Oolite times.

The granitic boulders may have been carried to their present position by floating trees borne by currents from the eastern land; or they may have formed part of a small island which had been gradually reduced in size by the encroachments of the sea till a more rapid subsidence enabled the waves to complete its destruction; the last peak of the microgranulite may have been broken up in a storm, and its component blocks scattered over the surrounding sand-banks. Let us hope that other borings in Buckinghamshire may afford further information on this point; and if I were asked to indicate a site for a trial boring in search of the Palæozoic floor with its possible Coal-measures, I should mention the neighbourhood of Aylesbury.

VI.—Palæontology in the Malton Museum.

By A. Smith Woodward, F.G.S., F.Z.S.

AMONG the local Museums of recent foundation, it would be difficult to find one of more scientific interest and importance than that of the Malton Field Naturalists' and Scientific Society. The commencement of the collection, indeed, was made so lately, that it might naturally be expected to have attained little beyond the nucleus-stage; but as an exponent of local Natural History it already rivals many of the older Museums, and the object of the present notice is briefly to call the attention of palæontologists to the material it affords for all interested in the investigation of Jurassic and Cretaceous fossils.

The oldest portion of the Palæontological collection is a series of Corallian fossils obtained many years ago in the neighbourhood of Malton by Mr. S. King; but the recent discoveries form by far the greater portion of the series, and these have been collected by Mr. Samuel Chadwick, F.G.S. The only difficulty presented to the student is the limited amount of cabinet and exhibition space, which renders it impossible to arrange more than a small typical collection, and it is to be hoped that, ere long, the Society will be in possession of sufficient funds to erect the long-projected new building, and rescue the stowed-away treasures from the dark cellars in which they are still placed.

The Upper Lias of Whitby is represented to a considerable extent; but the later Jurassic formations occurring in the immediate vicinity of Malton naturally claim the largest series of specimens. In addition to the Corallian Mollusca and some Echinodermata and Crustacea, a few Sponges have lately been discovered upon this horizon by Mr. Chadwick, and are now being investigated by Dr. G. J. Hinde; and both Reptiles and Fishes are represented by numerous teeth and spines. The Yorkshire Chalk has also yielded a large number of specimens—the collection of Sponges from Flamborough being, indeed, enormous.

Such a collection necessarily affords much of interest to the specialist, and the present writer's notes, made during a recent visit under the guidance of Mr. Chadwick, relate exclusively to the Fossil Vertebrata.

Among the fossils of the Whitby Lias, in addition to remains of the ordinary Reptiles, there are numerous portions of the gigantic Acipenseroid Fish, *Gyrosteus*, displaying some of its characteristic features, as lately described in the Proceedings of the Geologists' Association. A detached fin, probably of *Gyrosteus*, showing a sparse investment of dermal prickles, seems to be unique; and two portions of the tail exhibit the characters of the caudal scutes, previously only observed in a specimen in the York Museum. Both the fin and the caudal scutes differ in little except size from the corresponding parts of *Chondrosteus* met with in the Lower Lias of Lyme Regis; but the more important structural features of the Whitby fish seem to demonstrate its distinctness from the latter genus.

In the Corallian beds of Malton Reptiles are only represented by detached teeth and imperfectly preserved bones, chiefly Plesiosaurian and Pliosaurian. Fishes, moreover, occur in an equally fragmentary state, but are somewhat more varied and abundant. Among these the fine series of teeth of *Hybodus obtusus* described by Mr. H. M. Platnauer,[1] is conspicuous; and there can be no doubt as to the correctness of the specific identification. A characteristic dorsal fin-spine of *Asteracanthus ornatissimus* has already been noticed by Mr. Chadwick;[2] and it is interesting to find, upon the same horizon as this fossil, portions of the large cephalic spines well known to occur with remains of *Asteracanthus* in the Oxford Clay near Peterborough.[3] No *Strophodus*-shaped teeth, however, have as yet been discovered at Malton. Several slender, pointed Selachian teeth are exactly of the form long ago described by Agassiz, under the preoccupied name of *Sphenodus*,[4] from the Jurassic rocks of the Continent; and no fossils of this character have hitherto been recorded from British strata. There is also an Ichthyodorulite indistinguishable from the dorsal fin-spine of the existing *Cestracion*—a genus believed to occur fossil in the Lithographic Stone of Bavaria, and the possible discovery of the teeth of this Shark in the Yorkshire Corallian will be awaited

[1] Ann. Report Yorksh. Phil. Soc. 1887, p. 35, pl. i. figs. 1–16.
[2] Third Annual Report Malton Field Nat. and Sci. Soc. 1885–86, p. 6.
[3] Ann. & Mag. Nat. Hist. [6] vol. ii. p. 340, pl. xii. figs. 7-8.
[4] *Orthacodus*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. (1889), p. 349.

with interest. Several teeth of Chimæroid fishes pertain to *Ischyodus*, among which may be recognized the Middle and Upper Jurassic species *I. Egertoni*; and some very fine examples of tooth-bearing jaws indicate the presence of a Pycnodont Ganoid, probably *Gyrodus*.

A tooth of *Ptychodus* from the Middle Chalk of East Lutton seems to be referable to *P. rugosus*; and the common Cretaceous Shark, *Lamna appendiculata*, is represented by a tooth from the Lower Chalk of Wharram Grange.

Acquisitions of all kinds are continually being made, chiefly through the researches of the Honorary Curator, Mr. Chadwick; and much that is novel and interesting is being met with in nearly all departments.

REVIEWS.

I.—Publications of the Geological Department of the British Museum (Natural History). Catalogue of the Fossil Cephalopoda (Part I.). By Arthur H. Foord, F.G.S. 8vo. pp. xxxii. and 344. Illustrated with Fifty-one Woodcuts. (1889, London, Trübner & Co.)

DURING the past eight years, a very valuable series of Catalogues have been published, under the authority of the Trustees, descriptive of various portions of the fine Collection of fossil organisms preserved in our great National Museum of Natural History. One of the latest of these, by Mr. A. H. Foord, issued in January last, gives us the first instalment of what cannot fail to be a most acceptable contribution to our knowledge of the testaceous remains of that ancient group, the Cephalopoda, which in Scandinavia, Bohemia, and elsewhere, often form entire beds of limestone with their many-chambered shells.

So much having been published of late years both in Europe and America upon the Cephalopoda, it became extremely desirable to have a Catalogue of our own National Collection, in order that we might know how far it could be deemed to be a fairly-complete representation of what must certainly be looked upon as the highest, and also the most interesting class of the Mollusca.

If we may form a criterion of the whole collection from the present Catalogue, which embraces seven families only, namely, the Orthoceratidæ, the Endoceratidæ, the Actinoceratidæ, the Gomphoceratidæ, the Ascoceratidæ, the Poterioceratidæ, and the Cyrtoceratidæ, which are only a part of the suborder Nautiloidea, we have a right to conclude that the Cephalopoda are remarkably well represented in the Geological Department, and that this Catalogue, when completed, will be one of the best of its kind ever produced.

Under each genus, the generic characters are carefully given, and similarly under each species the synonymy and references, the specific characters, with the horizon and locality of each, and remarks upon the specimens described. In fifty-one instances the species are figured as woodcuts in the text carefully drawn with the author's own hand.

The introduction contains a most excellent review of the progress of research by students of the Cephalopoda, amongst the most able of whom are Barrande, Nœtling, Zittel, Mojsisovics, Hyatt, and Blake, besides many others.

To Prof. Hyatt we are indebted for a vast amount of most patient and exhaustive research into the origin, structure and modes of growth of the cephalopod shell; and whether we agree in whole, or only in part, with his views, we cannot but admire the great amount of excellent work which he has achieved. Like other primitive groups, the Cephalopoda have not escaped the efforts of the embryologists, who, basing their classification upon the difference in the structure of the initial chamber in the Ammonoidea and the Nautiloidea, have placed the former in the Dibranchiata, on the ground that the nucleus (protoconch) in the *Ammonites* agrees with that of *Spirula*, rather than with that of *Nautilus*. Hyatt however has found the shrivelled remains of the protoconch in two species of *Orthoceras* (*O. elegans*, and *O. unguis*), which he has figured in "Science" for Feb. 1884, p. 126. But the importance of such a character for purposes of classification is very doubtful. Indeed, Dr. Zittel has well pointed out that no special systematic value has been attached to the presence or absence of the embryonic shell (nucleus) in the Gasteropoda, which corresponds with the initial chamber of the shells of Cephalopoda, and ought to be, and indeed no doubt is, of equal value (Introduction, pp. vii and viii).

Of course, in the absence of all the soft parts of the animal, advantage has to be taken, for purposes of classification, of all the various points of structure of the shells of these Palæozoic Molluscs.

In considering the development of the siphuncle, Professor Hyatt has assumed that the ancestral forms of the Cephalopoda had closed cæca instead of a siphuncle, and that these were the "initial stages" of the necks of the septa; he further imagines that these cæca, "becoming prolonged in descendant forms, were differentiated into the funnels, the remnants of the cæca and the thinner walls of the sheath proper connecting them were formed by the fleshy siphon. This is the condition of the siphon in the typical forms and in the tubular-siphoned *Orthoceras*, but in some aberrant genera [*Endoceras* and *Piloceras*] the fleshy siphon widens near the living chamber, becoming conical and forming a sheath. These sheaths lie in the large tube formed by the true funnels, and may deposit permanent diaphragms as in *Endoceras*."

Since Hyatt wrote the foregoing, new light has been thrown upon this subject by the discovery of the initial chamber of *Endoceras*, by Dr. Gerard Holm, of Upsala. The enormous size of this chamber, which is continuous with the siphuncular cavity, lends countenance to Dr. Zittel's view that the siphuncle was originally a remnant of the visceral sac. A similar opinion was enunciated by Dr. H. Woodward in his paper "On the Structure of Camerated Shells,"[1] in which, after quoting Owen's statement regarding the connection between the *Nautilus pompilius* and its shell, to the effect that a

[1] "Popular Science Review," 1872, vol. xi. p. 113.

third point of attachment is to the bottom of the shell by the posterior extremity of the mantle, which probably presents a conical form in the embryo Nautilus, he continues, if then, the siphuncle in the young stage forms the main point of attachment between the animal and its shell, we may reasonably argue that the siphuncle in the adult Nautilus is simply the evidence of an aborted embryonal organ whose function is now fulfilled by the shell-muscles, but which in the more ancient and straight-shelled representatives of the group (the Orthoceratites) was not merely an embryonal, but an important organ of attachment between the animal and its shell in the adult.

It has been observed, however, that the shell-muscles in *Nautilus* are incapable of bearing even a slight strain, and that the animal seems readily able to detach itself from its shell when injured (see Introduction, p. xi).

Full justice is done by Mr. Foord in his "Introduction" to all the various writers on the Cephalopoda, and the views of M. Barrande on the appearance in time and the distribution, both in time and space, of the several families of the Nautiloidea, are fully given.

Mr. Foord quotes the opinion of von Jhering, Prof. Hyatt, and S. P. Woodward, that probably *Tentaculites* may have been the prototype of the Cephalopoda, an opinion, however, which Prof. James Hall does not share (p. x).

In the search for connecting links between the Nautiloidea and Ammonoidea, our attention is arrested by the peculiar form *Bactrites*, which, though probably a true Nautiloid, is connected by its ventral sutures with the Ammonoidea through *Mimoceras*, Hyatt. Again, in the Clymenidæ and Goniatitidæ of the Devonian and the Carboniferous and in the Ceratitidæ of the Trias a very decided approach is made towards the complicated sutural line of the Ammonoidea. It is worthy of note also that the Goniatitidæ, which are in many respects Nautiloid in their characters, made their first appearance in the Devonian, and therefore after the Nautiloidea had attained their maximum of development, which took place in the Silurian epoch.

Concerning the first appearance and distribution of the earlier forms of life in the European area, it has been suggested by Dr. Hicks that they originated in the warmer or more equatorial regions, where it is probable that the principal changes in their development took place; and that they gradually migrated northwards as the thermal conditions became more favourable, owing to the subsidence of the land and the consequent spread of the seas in Northern latitudes. Here "the groups as they successively appeared always contained evidence of advance in development over those which had previously reached the areas."

The result of recent discoveries relating to the structure of the shells of *Endoceras*, *Piloceras*, *Actinoceras*, and *Ascoceras* will be found under the descriptions of those genera, with the exception of *Ascoceras*, some new facts having come to light regarding that genus since the description of it was printed: these facts are detailed in the Supplement (p. 334), at the end of the volume, and

have been given even more fully with figures in this MAGAZINE for December, 1888, by Dr. Gustav Lindström (p. 532), and subsequently in March last by Mr. A. H. Foord (p. 121).—*Introduction*, pp. xvii and xviii.

Besides giving a "Table of the Nautiloidea," prepared with a view to show the groups into which the species described by the author have been subdivided, Mr. Foord has also provided an excellent quarto table of the classification of the Lower Palæozoic rocks of Europe and North America, giving as nearly as possible the corresponding horizons for Britain, Scandinavia, Russia, Bohemia, France, and North America. This in itself forms a most valuable boon to the scientific worker, and will prove highly acceptable for other groups besides the Cephalopoda.

We are greatly indebted to Mr. Foord for this his first instalment of a Catalogue of the Fossil Cephalopoda in the British Museum, and we trust he will not rest until he has completed this great work, and we, for our part, will continue to pray for its speedy delivery by Messrs. Taylor and Francis, equally well executed in its entire form as is the volume now before us.

II.—CATALOGUE OF THE FOSSIL FISHES IN THE BRITISH MUSEUM (NATURAL HISTORY). PART I. CONTAINING THE ELASMOBRANCHII. By ARTHUR SMITH WOODWARD, F.G.S., F.Z.S. 8vo. pp. xlvii. and 474, with 17 Plates and 15 Woodcuts. (London, Trübner & Co., Printed by order of the Trustees.)

UNDER the above modest title we are presented with an important systematic and descriptive work on the Taxonomical bearing and position of the extinct Elasmobranch Fishes, and their relation to existing members of the group.

The fossil forms are numerous, and range in geological time from the deposition of the Lower Carboniferous rocks—and even earlier, assuming that certain spines, from Devonian and Silurian deposits, really belong to Elasmobranch fishes—and through all subsequent geological periods into the later Tertiaries. The geographical range is also co-extensive with that of the other subclasses of extinct fishes.

The fossil remains, with few exceptions, and these mostly of recent acquisition, consist mainly of unconnected portions of cartilage, vertebræ, bony spines (Ichthyodorulites), and teeth. This dissociation of important parts greatly puzzled the earlier naturalists in their efforts to determine the nature and connection of these fragments with each other; and also in realizing the near affinity of some of the extinct forms to existing genera. But the researches of later investigators, with far greater facilities for comparison and intercommunication, combined with the discovery in some localities of specimens more or less completely preserved, have minimized many of the difficulties encountered by the pioneers of the science. But, notwithstanding these advantages, the modern exponent still has his difficulties, as he must very often base his conclusions with regard to the genus, species, or the affinity of a fossil fish upon a mere fragment of its organism.

In the preparation of the Catalogue, which is much more than a classified compilation of families, genera, and species, the author has studied the best works of the latest writers on the Taxonomy and Morphology of the group, whether palæontological or zoological, and with manifest advantage. He adds a few brief comments on some systems of arrangement hitherto proposed, and on a few of the various opinions regarding the affinities of certain forms. The volume also contains many valuable original descriptions, observations, and revisions of importance. The aim and scope of the work is related in the opening paragraph of the Introduction, which we reproduce. The author states: "The present volume being the first attempt at a systematic treatment of the Palæontology of the Elasmobranch fishes, it seems a fitting occasion for briefly reviewing the bearing of the newly collected evidence upon the various results that have already been attained in the study of the existing members of this great subclass. Notwithstanding its imperfections, Palæontology must necessarily be employed as the test—if it be not adopted as the basis—for all morphological and taxonomic speculations; and though the pages of the Catalogue may indicate extreme imperfection in our knowledge of the past history of most groups, there are still a few well-ascertained facts which may be already profitably discussed with reference to the conclusions of recent Zoology."

"It is therefore proposed:—firstly, to enumerate the principal stages by which the most modern schemes of classification of the group have been elaborated; secondly, to summarize the known and available resources; thirdly, to recapitulate the more important palæontological results; and lastly, to discuss these results in the light of modern theories of taxonomy."

Under the heading "Taxonomic Deductions from the Study of Recent Elasmobranchs," the author gives a brief summary of the diverse classifications, and the varying terminology adopted or proposed by naturalists of repute, to distinguish the existing fishes assigned to the cartilaginous group; the following being the most important, commencing with Willughby and Ray, who "inaugurated the era of modern Ichthyology in 1686." These authors "assigned to the PISCES CARTILAGINEI, the Lampreys, Sharks, Rays and Sturgeons." This arrangement was accepted by Artedi (1738), who made the group an "order" named CHONDROPTERYGII. It was afterwards adopted by Linnæus, who enlarged the group by the addition of other forms, "and proposed the new term of AMPHIBIA NANTES." In 1806 Duméril, following Lacépède, who had returned to Artedi's conception of the Chondropterygii, proposed the name of TRÉMATOPNÉS for the fishes "possessing neither operculum nor opercular membrane," to contain two "families" which he termed Cyclostomes and Plagiostomes. "The latter group comprised the Sharks and Rays," the Chimæroids being "placed far apart." Cuvier later on added the Chimæroids to the Plagiostomes and renamed the group *Selachiens*. Bonaparte (1832-1841) "proposed to elevate this group into a subclass of Elasmobranchii, the two subdivisions to be regarded as orders and known respectively

as *Selacha* (Sharks and Rays) and *Holocephala* (Chimæroids);" and the Cyclostomes to constitute a distinct subclass. Agassiz about the same time "reunited these two subclasses under an order termed *Placoidei*." "In 1846 J. Müller adopted Bonaparte's subclasses, though using the term *Selachii* as equivalent to Elasmobranchii, and naming the two orders, Plagiostomi and Holocephali." Bonaparte's classification was also adopted in 1870 by Dr. Günther, but he termed "the subclasses Chondropterygii and Cyclostomata respectively, and the orders of the former *Plagiostomata* and *Holocephala*; while the Plagiostomes were further divided into the suborders of Selachoidei and Batoidei." But in 1871 Dr. Günther instituted his subclass PALÆICHTHYES, of which the Chondropterygii became an order, and Plagiostomata and Holocephala were reduced to suborders. In the same year Prof. Cope proposed to unite the Sharks and Rays in one subclass (SELACHI) and the Chimæras to form another (HOLOCEPHALI); "this arrangement being based upon the fundamental difference in the structure of the skull already indicated in Bonaparte's second term." This classification was accepted by Prof. Huxley in 1876, but he regarded the two groups as orders, "and preferred the term Plagiostomi to that of Selachi." Our author also adopts Cope's classification, and adds, "Most modern researches have also tended to emphasize the distinction between fishes with autostylic, and those with hyostylic skulls, both among those without membrane-bones and those possessing these skeletal elements; and such is the arrangement selected for adoption on the present occasion."

"With regard to terminology," the author observes, "the only term originally restricted to the cartilaginous hyostylic fishes is that of 'Plagiostomi,' proposed by C. Duméril; but this is both inappropriate in many instances, and also based upon a misconception of the supposed relationship existing between the Lampreys and the Sharks. We therefore venture to follow Prof. Cope in adopting Bonaparte's name, Elasmobranchii, excluding the Holocephali, and elevating these to the rank of an equivalent subclass."

Prof. Cope, in 1884, established a new order of the Elasmobranch subclass, based upon his studies of some fish remains from the Permian beds of Texas, possessing teeth of the Diplodus type, and also exhibiting "an arrangement of the mandibular and hyoid arches extremely similar to that observed in the living *Notidanus*." There are other supposed distinctive structural characters of the cranial elements; and upon these fossils Prof. Cope founds his genus *Didymodus*, to be included with Pleuracanthus and the Hybodontidæ in an order he terms ICHTHYOTOMI.

The necessity for forming a new order for the reception of *Pleuracanthus* has also recently (1888) been remarked by M. Charles Brongniart, who has been able to study numerous specimens of the genus, in fair preservation, obtained from the Middle Coal-measures of France. The evidence thus attained enables him to attempt the restoration of the entire skeletal structure of the fish; and to suggest inclusion in a new order which he proposes to term "Pleuracanthides."

Again, with regard to subordinal divisions. Sir Richard Owen in "Palæontology" (1860), ranks the Plagiostomi as an order, and recognizes four families: the Cestraciontidæ, including the living Port Jackson Shark and the fossil forms supposed by Agassiz to be allied to it; the Hybodontidæ for the extinct Hybodonts; and the Squalidæ and Raiidæ for the Sharks and Rays. Subsequently (1866), he elevated these families into suborders, the Squalidæ becoming Selachii, the Raiidæ, Batides; and the Cestracionts and Hybodonts forming one suborder named Cestraphori, "in allusion to the presence of dorsal fin-spines."

In 1882 Prof. C. Hasse proposed as the result of his studies of the axial skeleton, a classification "based upon the varied conditions of the notochord and the vertebræ," founding thereon four groups which he named respectively: *Palæonotidani*, in which the notochord is persistent; the *Cyclospondyli*, with partial calcification at intervals in the notochordal sheath, represented by the Spinacidæ; the *Tectospondyli*, with numerous calcified rings, comprising the modern Rays, with their near allies the Pristiophoridæ and Squatinidæ; and finally, the *Asterospondyli*, in which the calcification is "so arranged as to appear radiating or star-shaped in vertical transverse section." The author deems this classification one of much significance; for the various modifications of the cranium afford no "satisfactory basis for the definition of subordinal groups," and the types of axial skeleton defined by Hasse correspond nearly with the accepted divisions of the Selachii, namely, the Sharks and Rays. Thus the "Tectospondyli" comprise the Rays and their near allies, the Pristiophoridæ and Squatinidæ, while the "Asterospondyli" include the Cestraciontidæ and other Sharks. Eliminating Hasse's first two groups, the members of which "may be variously distributed" in the other two, the author, in part, accepts this classification and terminology as being in his view the best to define the subordinal divisions of the group, and which is applicable alike to the extinct and recent forms. This arrangement has the merit of being simple as well as natural.

The numerous palæontological authorities consulted in the preparation of the Catalogue are enumerated, and the titles of their respective works annexed, forming a goodly list. The geological formations and localities whence the remains of the principal fossil groups have been derived are also briefly detailed.

The teeth and bony spines of fishes and other fossil remains have long been known, and greatly perplexed the early observers in their attempts to unravel their history. Thus, the teeth of Sharks were described as the petrified tongues of fishes, and named *Glossopetræ*.

An English author early in the seventeenth century [1] thus quaintly describes them:—"Potters, in working their clay which is gotten in some especiall place, doe find in it certaine things which are as hard as stone, and of the very forme and shape of the tongues of some

[1] Richard Verstegan, A Restitution of Decayed Intelligence, 1605.

sorts of fishes, each with the root unto it, to make it the very markable, and right proportion of such a kind of tongue in all respects." Their true nature was first made known by Steno in 1660, and later by Scilla in 1752, who compared them with teeth of recent Sharks. The bony spines were supposed to be jaws, and some even to be plants. That they were the dorsal fin-spines of extinct Elasmobranch fishes was first proved by Buckland and De la Beche about 1830, who proposed the term "Ichthyodorulites." "Agassiz named many of them, and assigned a few to their correct zoological position." Agassiz is also credited as being "the first to place the study of Elasmobranch Palæontology upon a truly scientific basis;" and his great work as still forming "the groundwork of the whole subject." The researches of numerous subsequent authors on the same subject, whether of a general character or limited to a description of the fauna of a geological horizon, of a country, or a district, are respectively noticed.

In a "Synopsis of Palæontological Results," the author states that the general results of these discoveries and investigations add much that is new, and the main points of biological significance are briefly enumerated.

To give an intelligible résumé of the descriptions of the internal and external skeleton and the dentition would exceed the limits of this notice. The respective portions described are first the "*Cartilage*"; and this, even in the Lower Carboniferous, "exhibits a considerable amount of calcification." The "*Head and Visceral Arches*" come next, and all that is known regarding the structure of the extinct Elasmobranch skull in the various genera is fully detailed. The structure of the "*Vertebral Column*," and its importance as an element in the classification of the group, has been already referred to. The structural characters of the "*Pectoral and Pelvic Arches and Fins*," respectively, and of the "*Median Fins*," follow; the "*Shagreen and Dermal Defences*" are the next objects of comment, and finally the "*Dentition*."

With respect to the adoption of a classification for the extinct Sharks and Rays, the author observes, that "the first point to be considered is the validity of Prof. Cope's division of the subclass into the two orders Ichthyotomi and Selachii." The first order was founded upon certain modifications observed in the structure of the skull, the pectoral fins, pelvic arch, and the axial skeleton of the European *Pleuracanthus* and the American *Didymodus*; these modifications being sufficiently pronounced as to justify an ordinal separation from the other groups of the subclass. But the principal character is the structure of the pectoral fin, in which the metapterygium forms a long segmented central axis, and as this structure "differentiates the Crossopterygii from the higher Ganoidei or Actinopterygii," the same character separates the Ichthyotomi—though perhaps less widely—from the Selachii. The order therefore, as here defined, is limited to those fishes that possess this type of fin. The reason for the inclusion of the Sharks and Rays in one order is explained by the difficulty of defining a distinct line of

demarcation between the Sharks with lateral gill-clefts and the Rays with ventral gill-clefts, seeing that there are many intermediate gradations of skeletal structure, of habit, and of external form by which one group passes into the other. Some of these gradations are enumerated in the following passage:—"The Squatinidæ and Pristiophoridæ, for example, possess lateral gill-clefts, like Sharks; but the structure of the vertebræ, the partial growth forwards of the pectoral propterygium in *Squatina*, and several striking resemblances existing between *Pristiophorus* and *Pristis* and *Rhinobatus*, all point to the Squatinidæ and Pristiophoridæ as probably survivors of ancestral Rays."

For the grouping of families and genera, "the arrangement formulated by Dr. Günther in his Catalogue of 1870 for the recent forms," is adopted, and where possible the "extinct families and genera will be incorporated among them."

We have referred at some length to this subject of classification, it being an important element in the work. Although Bonaparte's classification and terminology for the whole group is adopted, Hasse's subdivisions founded upon the structure of the axial skeleton, and Cope's new order based upon other structural characters, have been added; but each, as already stated, with modifications and restrictions, the result being an emphatically new classification, which appears to be, approximately, a good natural one, in our present knowledge of the fossil groups. The author modestly observes that "this Catalogue, however, can only be regarded as a provisional attempt to systematize and arrange the ascertained facts of Elasmobranch Palæontology for convenience of reference."

In the Catalogue a diagnosis of the principal distinguishing characters is attached to each order, family, genus and species respectively, with comments. The nature of the type specimen, where preserved, if known, and the formations and localities whence the various specimens have been derived, are also given. The synonyms of the genera and species, if any, also lists, with references, to all the species of each genus described, as far as ascertainable, but of which no specimens are in the Museum, are included. All these details have necessitated much labour and research, the result being a most valuable work of special reference.

The first Order, *Ichthyotomi*, as already mentioned, is limited to those fishes having a long segmented axis in the pectoral fins, analogous to that in the Ganoid Crossopterygians; it comprises the families PLEURACANTHIDÆ and CLADODONTIDÆ. To the former are assigned the genera *Pleuracanthus*, *Diplodus*, and *Chondrenchelys*. We have here, on the very threshold of the Catalogue, interesting evidence of the progress of recent palæontological investigations into the nature and relationships of various imperfect fragments described by previous authors, in the merging of many genera into one. Thus to the genus *Pleuracanthus*, founded by Agassiz for the reception of some barbed spines from the Coal Measures, are referred no less than thirteen genera, namely, *Diplodus*, *Orthacanthus*, *Xenacanthus*, *Triodus*, *Compsacanthus*, *Dittodus*, *Aganodus*, *Ochlodus*, *Pter-*

nodus, *Thrinacodus*, *Lophacanthus*, *Anodontacanthus*, and *Didymodus*. *Diplodus*, however, is provisionally retained for the teeth not correlated with spines.

Pleuracanthus decheni, a small species from the Lower Permian of Rhenish Prussia and elsewhere, has been long and is best known by numerous specimens in fairly complete preservation. With the exception of *P. Gaudryi* and *P.* (*Didymodus*) *texensis*, the other species are only known by teeth and the cephalic spines, the latter being placed on the head in advance of a small fin. Teeth and spines indicate that some species or individuals attained a large size. The remarkable, but imperfectly known *Choudrenchelys*, discovered by Dr. Traquair in the Lower Carboniferous rocks of Eskdale, is provisionally placed in this family on account of the resemblance to *Pleuracanthus* of the axial skeleton, the similarity of the form of the body and the presence of a long dorsal fin, but it has no cephalic spine. The CLADODONTIDÆ are "an indefinable family, apparently closely allied to the Pleuracanthidæ." Dr. Traquair has discovered the pectoral fins of the type genus *Cladodus*, and states that they possess the characteristic structure of the order. But with this exception, all the species of the family are only known by detached teeth, no spines being assigned to the group. Six genera are noticed, three being American, but of these there are no specimens in the collection. *Phœbodus* is a Devonian genus from Iowa. The other genera only occur in rocks of Carboniferous age.

We next come to the order SELACHII, and the suborder *Tectospondyli*, comprising twelve families, the first being the SPINACIDÆ, and the last the TRYGONIDÆ. The first family, Spinacidæ, contains fossil representatives of the existing genera *Centrina*, *Acanthias*, *Centrophorus*, *Spinax*, and *Scymnus*, hitherto classed with the Sharks. The fossil species of *Acanthias* and *Centrophorus* are from the Upper Cretaceous of Mount Lebanon, Syria.[1]

The PETALODONTIDÆ follow next, with nine genera. "The genus *Janassa* affords the most complete insight into the characters of this family;" the dentition of one species (*J. bituminosa*) from the Permian having been found in natural apposition. The other genera being only known by detached teeth and such fragmentary portions. A new genus and species, *Mesolophodus problematicus*; and two species of *Petalodus* (*P. flabellula* and *P. Davisii*) are here first described. With the exception of the Permian *Janassa bituminosa*, all the other species are from Carboniferous rocks. The SQUATINIDÆ have one genus, *Squatina*, and five species, two being Kimmeridgian and three Cretaceous. One new species (*S. crassidens*) from Mount Lebanon is described.

To the PRISTIDÆ a new genus and species (*Sclerorhynchus atavus*) is added, founded on an imperfect rostrum, also from Mount Lebanon.

[1] From this formation and locality the Museum possesses a large series of fish and other remains, remarkable alike for the numbers of genera, species, and of individuals represented, and also the beautiful state of their preservation. The collection contains many of the types of this subclass and also of the Ganoid and Teleostean fishes, described from this locality.

From the same locality the Museum contains four species of *Rhinobatus*, and the type specimens of three; the fourth (*R. maronita*) being in the Geneva Museum. This is the only genus of the Rhinobatidæ in the collection. The RAJIDÆ is also only represented by the genus *Raja*. The type specimens of three species, also from the Lebanon, are in the collection, one (*R. primarmata*) being here first described and figured. The well-known dermal tubercles from the Norwich Crag, named by Agassiz *Raja antiqua*, are now referred to the common Thornback (*R. clavata*).

The PSAMMODONTIDÆ, here classed with the Rays, were referred by Agassiz to the Cestraciont group. The family is extinct and only known by the dentition, and this shows "that the two rami of the jaws were evidently placed in the same straight line—a fact indicating a much depressed body, like that of existing Rays." It comprises the genera *Copodus* and *Psammodus*. The former consists of eleven species, of which all the type specimens are in the Museum; the latter of six species and some of the types. One new species (*P. salopiensis*) is described. The species are all Carboniferous, and the best known, *P. porosus*, is now referred to *P. rugosus*.

The MYLIOBATIDÆ come next with eight species of *Myliobatis*, all Tertiary. Only those known by the dentition are catalogued, and the published British species are reduced in number. The upper and lower series of connected dental plates are distinguished, the upper series are arched antero-posteriorly, the lower series being flat; and the barbed spines referred to the genus are generically indeterminable. One new species (*M. (?) tumidens*) from the Red Crag and also a new species of *Rhinoptera* (*R. Daviesii*) from the London Clay are described. The dental plates named *Zygobatis* by Agassiz were referred to this genus by Dr. Günther in 1880. *Aetobatis* is allied to the last-named genus, but distinguished by the absence of lateral teeth. The long familiar Cretaceous genus *Ptychodus*, and its many species, once prominent members of the Agassizian group of Cestracionts, is placed by the author in this family, he being the first to discover, by the arrangement of the dentition, its natural affinity to the Rays. The teeth were numerous in each mouth, and arranged in many longitudinal and transverse rows. The median antero-posterior row in one jaw is very small, the row on either side being much larger; in the other jaw the teeth of the median row are large, and those on each side smaller. *Ptychodus* is only known by the teeth and vertebræ. The vertebræ are "apparently 'cyclospondylic' in structure," and were found in immediate association with teeth of *P. decurrens* in a block of chalk. Many of Agassiz's types are in the collection; and there is one new species, *P. multistriatus*. The fin-spines and rays referred to this genus by Agassiz do not even belong to the same subclass. Of the TRYGONIDÆ, the only genus in the collection is *Cyclobatis*, with two species and the type specimens of each. This ends the Tectospondylic section.

Only six families are assigned to the suborder *Asterospondyli*, but the genera and species are many. The NOTIDANIDÆ is the first family, "its relationships," according to the author, "being

obviously closer with the Cestraciontidæ than with any other recognized family." Eight species of *Notidanus*—the only fossil genus known with certainty—are registered, the species ranging from the Jurassic rocks to the Red Crag inclusive.

The Cochliodontidæ come next—"an imperfectly definable family, apparently related to the Cestraciontidæ, but with a more specialized dentition." The group is restricted to the Carboniferous period, and includes many of Agassiz's Cestraciont genera. Of the nine species of *Helodus* originally named by Agassiz, only one (*H. simplex*), from the Coal-measures, remains, the others being variously distributed. We then have an innovation, a new generic name, *Pleuroplax*, as being more appropriate, is substituted for *Pleurodus*. *Psephodus* follows with two new species (*P. salopiensis* and *P. dubius*). A British species, *Sandalodus Morrisii*, from Oreton, appears to be the largest of the genus. In addition to the above named, the following genera are included in the family: *Tomodus*, *Xystrodus*, *Deltodus*, *Pœcilodus*, *Cochliodus*, *Streblodus*, *Deltoptychius*, *Diplacodus*, and *Cyrtonodus*. New species of *Deltodus* (*D. gibbus* and *D. rugosus*), and one of *Cyrtonodus* (*C. Hornei*), are added.

The Cestraciontidæ as here defined form an important group of fifteen genera and about seventy species. Of these only three genera (*Orodus*, *Strophodus*, and *Acrodus*) originally assigned by Agassiz to the family remain. The teeth are described as being "mostly obtuse, never fused into continuous plates; several series simultaneously in function;" and "no distinctive characteristics of value having yet been discovered, the so-called Orodontidæ and Hybodontidæ are included in the family." Its fossil representatives first appear in the Lower Carboniferous, and occur in more or less abundance in all the succeeding periods to the Chalk inclusive, the living Port Jackson Shark being the last survivor of the group. One of the earlier forms, *Sphenacanthus costellatus*, described by Dr. Traquair, is known by a fairly complete fish in the Museum having both dorsal spines in natural position; the other Carboniferous forms being mainly represented by detached teeth and fin spines. *Hybodus* is probably the most completely known genus of the family. Liassic and Wealden specimens in the collection show interesting portions of the cranial structure, the internal skeleton and the external form; also the dermal covering, the hooked cephalic spines (*Sphenonchus*), and the dorsal fin spines, each in their respective positions. Moreover, in its close ally *Acrodus*, the arrangement of the dentition is observed. Portions of nearly complete jaws of each genus with the teeth in natural apposition are figured.

The numerous Oolitic teeth named *Strophodus* are now practically known to belong to the Ichthyodorulites named *Asteracanthus* by Agassiz; *Strophodus*, however, being provisionally retained for the teeth not correlated with spines. The teeth named respectively *S. reticulatus* and *S. subreticulatus* have been found associated with the dorsal fin-spines of *Asteracanthus ornatissimus*, which name they now bear; Owen's *S. medius* is also a synonym. The author has discovered that the species was armed with cephalic spines resembling

those of *Hybodus* and *Acrodus*. *Palæospinax* (*Thyellina*), placed by Agassiz among the Squalidæ, now passes to this family; and some interesting specimens of the genus are described, including one new species from the Lias of Ohmden. A closely allied form is the author's Cretaceous genus *Synechodus*, originally referred to the genus *Hybodus*, and known by jaws, teeth, fragments of cartilage, vertebræ and shagreen.

To the genus *Cestracion*, the last of the group, is referred Sir Philip Egerton's genus *Drepanephorus*. Six new species of as many genera are described; and most of the types, either wholly or in part, are in this collection.

The Scylliidæ come next with seven genera. The first, *Palæoscyllium*, is represented by one species (*P. minus*), a new one from the Kimmeridgian of Bavaria. *Scyllium* follows with six species, all Cretaceous, two being new, *S. dubium* from the Lower Chalk, Dover, and *S.* (?) *tumidens* from the Lebanon. *Cantioscyllium decipiens* is a new genus and species, founded upon the character of the dentition, recently exposed by the removal of the matrix on one of Agassiz's figured types (tom. iii. pl. xxxviii. fig. 2) of *Scylliodus antiquus*.

To the Lamnidæ are assigned eight genera, represented by forty-six species; but the teeth of the fossil genera are separated by characters so slight that it is difficult in some instances to distinguish them. Thus *Odontaspis* only seems to differ from *Lamna* in "the greater relative size and more subulate character of its anterior teeth." *Oxyrhina*, again, "only differing from *Lamna* in the prevailing absence of lateral denticles in the teeth." Again, *Lamna*, by *Oxyrhina mantelli*, "appears to be connected with *Oxyrhina*; and by *Lamna obliqua*, with *Carcharodon*." *Orthacodus* is a new generic name proposed for Agassiz's *Lamna* (*Sphenodus*) *longidens*, and *Scapanorhynchus* is another new genus founded upon several more or less perfect specimens from the Lebanon Cretaceous beds, and replaces the genus *Rhinognathus* of J. W. Davis; from the same locality a new species (*S. elongatus*) is described, and a tooth (*S. gigas*) from the Cambridge Greensand. To the same genus are also assigned the Cretaceous teeth respectively known as *Lamna* (*Odontaspis*) *rhaphiodon* and *L. subulata*.

To *Odontaspis* are assigned the teeth universally known as *Lamna elegans*, also the other species of *Lamna* having the same general form of tooth. *Otodus* disappears, the species being absorbed in the genus *Lamna*, which is thus defined: "Dentition only differing from that of *Odontaspis* in the relatively less elevated and less subulate character of the anterior teeth, and the usually larger size of the lateral denticles." One new species is described. Then comes *Carcharodon* with five species, all of Tertiary origin. One species, *C. megalodon*, attained an enormous size, and was very widely distributed. The teeth referred to the genus *Corax* are comparatively small, compressed and serrated.

The last family is the Carchariidæ. Of the type genus *Carcharias*, species of three of its five subgenera are in the collection, and there are two new species. The other genera composing the family, and represented by species, are *Galeocerdo*, *Hemipristis*, *Galeus* (?), and *Sphyrna*.

Having briefly sketched, without criticism, some of the main points of the classification here formulated for the arrangement of the fossil Elasmobranch Fishes, we have only to add that it is based principally on the study of the structural characters, and an intimate knowledge of the numerous remains in the collection whose arrangement forms part of Mr. Woodward's official duties; and also on the study of many specimens in private or public collections. Wherever possible, the fossils have been carefully compared with recent forms, and, as we have seen, other systems of arrangement have been studied with a view to their adoption, wholly or in part. The result is a palæontological classification, apparently the most natural and practical hitherto suggested for this group of extinct fishes. Modifications, sooner or later, will probably have to be made when more is known regarding the structure and affinities of the obscurer forms, but this cannot affect the principle on which it is based. We commend the author for its inception, and also for the industry displayed in the preparation of the Catalogue, and shall look with interest for the publication of the second part, which we understand will contain the Holocephali and Ichthyodorulites.

Six new genera and thirty-one new species are described, and most of them figured.

Of the 17 lithographic plates, seven are double, and the whole contain about 230 figures, while there are 15 woodcuts in the text.

The fossils have been drawn from nature by Miss G. M. Woodward with her usual fidelity to form and structure, and we would specially note the beautiful rendering of the ornamentation on the teeth of *Acrodus* in plates xiii. and xiv. W.D.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 5, 1889.—Prof. J. W. Judd, F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "Observations on some undescribed Lacustrine Deposits at Saint Cross, Southelmham, in Suffolk." By Charles Candler, Esq. Communicated by Clement Reid, Esq., F.G.S.

These deposits are situated in the basin of the River Waveney, $3\frac{3}{4}$ miles E. by N. of Harleston, and 9 miles E.N.E. of Hoxne. They occupy a hollow in the Boulder-clay towards the northern edge of the plateau locally known as "High Suffolk." Saint Cross brickyard, which is the only section now visible, shows:—

	ft.
a. Surface-soil and gravel	1–3
b. Red and white loam, variable, fine or coarse, sandy or calcareous. Elephant, Horse, etc., at base of the bed	3–5
c. Fine, tenacious, grey and red clay, with carbonaceous seams towards the base. *Valvata*, *Bythinia*, *Pisidium*.	2–5
d. Black peaty loam and sand, worked to a depth of 5 feet, but no bottom reached. Seeds and freshwater shells	5–
e. Chalky Boulder Clay	

No implements have yet been found in any of the beds; but Pleistocene Mammalia (determined by Mr. E. T. Newton) occur in

bed *b*. From bed *d* Mr. Clement Reid obtained seeds of 29 species of flowering plants. These are all marsh or aquatic species, except the hawthorn and dandelion. Unlike those found in Professor Prestwich's bed *d* at Hoxne, there are no Arctic forms among them; but the author pointed out that the Arctic plants of Hoxne were determined from *leaves* found in laminated clays, while the matrix in which the plants are found at St. Cross is only suitable for the preservation of seeds. However, certain of the plants do not range far north, and the occurrence of a large tree in the upper part of bed *d* points to a less rigorous climate than that under which the leaf-bearing beds at Hoxne were deposited.

The lacustrine beds now occupy a ridge between two depressions, the valleys having been deeply eroded, or perhaps formed since the filling-up of the lake. It appears probable that on the final retreat of the last ice-sheet the hollows of the Boulder-clay were occupied by a series of lakes and pools. For the most part the sedimentary deposits formed in these hollows have been entirely swept away; but at Saint Cross the mud and loam of one such lake have been preserved.

2. "On certain Chelonian Remains from the Wealden and Purbeck." By R. Lydekker, Esq., B.A., F.G.S.

In the first part of the paper the author described a portion of the hind lobe of a Chelonian plastron from the Wealden, which was remarkable as showing a median row of epidermal shields. The name of *Archæochelys valdensis* was proposed for the form so represented. The new generic term *Hylæochelys* was also proposed for the Purbeck Chelonian described by Sir R. Owen as *Pleurosternum latiscutatum*, and was also taken to include some other forms from the Wealden.

The second section of the paper treated of the affinities of *Pleurosternum*. It was concluded that *Digerhlum*, Cope (as represented by the so-called *Platemys Bullocki*), is identical with *Pleurosternum*, of which there appears to be only one Purbeck species. Evidence was brought forward to show that in the adult of *Pleurosternum* the pubis had a facet of articulation with the xiphiplastral; and it was proposed to refer this genus, together with *Platychelys* and *Baëna*, to a new section termed "Amphichelydia," which was regarded as allied both to the true Cryptodira and to the Pleurodira.

3. "On the Relation of the Western Beds or Pebbly Sands of Suffolk to those of Norfolk, and on their Extension inland; with some Observations on the Period of the final Elevation and Denudation of the Weald and of the Thames Valley." By Prof. Joseph Prestwich, M.A., D.C.L., F.R.S., F.G.S. Part I.

The author in this, the first part of his paper, described the Westleton beds of the East Anglian coast. He commenced with a review of the work of previous writers, especially Messrs. Wood and Harmer, and the members of H.M. Geological Survey, including Messrs. H. B. Woodward, Whitaker, and Clement Reid. In discussing this work, particular attention was paid to the Bure-valley beds, which were considered as a local fossiliferous condition of the Pebbly Sands; but the term is not so applicable to these sands as

that of the "Westleton and Mundesley Beds," which the author proposed in 1881.

The Westleton Beds were carefully described, as seen in coast-sections in East Anglia, proceeding from south to north, and the following classification was adopted:—

The Westleton and Mundesley series (the Mundesley section of it).	1. Laminated clays, sand, and shingle with plant-remains and freshwater shells (the Arctic forest-bed of Reid). 2. Sand and quartzose shingle with marine shells (the *Leda myalis* bed of King and Reid). 3. Carbonaceous clay and sands with flint-gravel and pebbles of clay, drift-wood, land and lacustrine shells and seeds (the Upper freshwater bed of Reid).
The Forest-bed series of Reid (exclusive of No. 3 of above).	4. A greenish clay, sandy and laminated in places, containing abundant mammalian remains, and drift-wood, with stumps of trees standing on its surface (the forest- and elephant-bed of authors; the estuarine division, in part, of Reid). 5. Ferruginous clay, peat, and freshwater remains and gravel (the Lower freshwater bed of Reid).

The Westleton Beds were found to rest with discordance on various underlying beds; in places on the Forest series, elsewhere on the Chillesford Clay, whilst occasionally the latter had been partly or entirely eroded before the deposition of the Westleton Beds. In the north, where the present series dies out, they come in contact with the so-called Weybourn Crag, which the author supposed to be the equivalent of the Norwich Crag. A similar discordance has been noted between the Westleton Beds and the overlying glacial beds, so that the former mark a distinct period, characterized by a definite fauna, and by particular physical conditions. The Westleton Beds being marine, and the Mundesley Beds estuarine and freshwater, the author proposed to use the double term to indicate the two facies, as has been done in the case of other deposits. But these facies were found to be local, and the most persistent feature of the beds is the presence of a shingle of precisely the same character over a very wide area. By means of this the Westleton Beds can be identified far beyond East Anglia, and where there is no fossil evidence, and they throw considerable light on important physiographical changes.

The author described the composition of the shingle, which, unlike the glacial deposits, contained pebbles of southern origin.

The paper concluded with a list of fossils, excluding those of the Forest-bed (the stumps of which, the author considered, were frequently in the position of growth). Should the Forest-bed eventually prove to be newer than the Chillesford beds, it was maintained that the former must be included in the Westleton series, and its flora and fauna added to the list, whilst if, on the contrary, the Forest-bed should be proved synchronous with the Chillesford Beds, it must be relegated to the Crag.

The second part of the paper will treat of the extension of these beds into and beyond the Thames Valley, and on some points connected with the physical history of the Weald.

II.—June 19, 1889.—Prof. J. W. Judd, F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On Tachylyte from Victoria Park, Whiteinch, near Glasgow." By Frank Rutley, Esq., F.G.S.

This paper dealt with the microscopic characters of certain thin tachylytic selvages occurring on the margins of white-whin (basalt) veins which traverse Carboniferous shales in Victoria Park, and which have already been described in some detail by Messrs. John Young and D. Corse Glen. The white-whin veins, which sometimes are not more than an inch in breadth, are found to become gradually more vitreous in passing from the middle to the sides of the veins. Near the margin they become densely spherulitic, the spherulitic band on either side of the vein being followed by a less spherulitic and more glassy band, the vitreous matter of which appears nearly or quite colourless. A sharp but irregular boundary-line follows, beyond which lies a band of a more or less deep brown or coffee-coloured glass, which the author considers to have resulted from the fusion of the shale, two narrow vitreous bands of different origin being thus developed side by side on each side of the vein, the colourless bands representing the chilled margins of the vein, the brown bands the fused surfaces of the walls of shale. The author only suggested this as a plausible explanation of the microscopic phenomena. An analysis of portion of one of these whin veins with its adherent tachylyte, made by Mr. Philip Holland, was appended to the paper.

2. "The Descent of *Sonninia* and of *Hammatoceras*." By S. S. Buckman, Esq., F.G.S.

The author reviewed the history and literature of the genus *Sonninia*, Bayle, which was founded to receive the Ammonites of the *Sowerbyi*-group, formerly classed, together with those of the *Insignis*-group, in the genus *Hammatoceras*.

The reasons why the genus *Sonninia* is not descended from *Hammatoceras*, or from *Haugia* (*Variabilis*-group), were set forth. Then, proceeding to trace out the life-history of *Pleuroceras*, *Amaltheus*, and *Sonninia*, as shown by their inner whorls, the author arrived at the conclusion that these three genera were descended from a common source, and that they form three branches from one stem.

The development of the genus *Hammatoceras*, *sensu stricto*, was then traced out, and its descent shown to be from the genus *Deroceras*, which is in accordance with the general ideas upon the subject.

The difference in the descent of *Sonninia* and *Hammatoceras* was taken to justify the separation of the former from the latter. The genus *Sonninia* would be correctly placed in the family Amaltheidæ; while the genus *Hammatoceras* would be placed in the same family as *Stephanoceras*.

Of the numerous new species belonging to the genera *Sonninia* and *Hammatoceras*, certain forms, necessary to elaborate the ideas set forth above, were described and definitely separated. The paper also touched upon certain other facts connected with *Hammatoceras*, *Sonninia*, and cognate genera.

3. "Notes on the Bagshot Beds and their Stratigraphy." By H. G. Lyons, Esq., R.E., F.G.S.

The author deplored the necessity of quitting the area which he had studied before completing his observations, and wished to place his results at the disposal of other workers.

In a previous paper he had discussed the beds at their southern outcrop, over a small area, and showed that there the Bagshot and London Clay strata remained of constant thickness, and dipped northwards at an angle of about $2\frac{1}{4}°$. He had since examined the country between Aldershot and Ascot over an area of about fifteen miles square, and attempted by contouring the surface of the Middle Bagshot beds (which showed a nearly constant thickness of 60 feet over the area), to give the form into which the beds had been pushed by the different slight flexures which might occur. After giving details of the heights at which this surface was found, he concluded that an anticlinal of which the axis pointed upon Windsor Castle, appeared to pass through the Swinley and Wellington College area, and probably to Hazeley Heath; and that a synclinal started by Minley and Hawley, and ran by the Royal Albert Asylum, Gordon Boys' Home, upon Ongar and Row Hills, and Woburn Hills; and that another anticline ran to St. George's Hill, Weybridge.

The author had attempted to map the southern and eastern limits of the Upper Bagshot beds, and claimed a much greater extent for these beds in those directions than had been assigned by the members of the Geological Survey. The outcrop of the beds was described in some detail, and the occurrence of outliers on Knaphill Common, by Donkey Town, on Chobham Common, and on Staples Hill, was noted.

4. "Description of some New Species of Carboniferous Gasteropoda." By Miss J. Donald. Communicated by J. G. Goodchild, Esq.

The Gasteropoda described in this paper have, with one exception, been collected by Mr. John Young from the Upper Limestone Series of Scotland. After discussing the characters of the genus *Orthonema*, Meek and Worthen, the following forms were described: *Orthonema pygmæa*, n. sp.; *O.* ?, n. sp.; *Murchisonia turriculata*, de Kon. (Yoredale Shales, Askrigg, Yorkshire); *M. turriculata*, var. *scotica*; and *M. compacta*, n. sp.

5. "*Cystechinus crassus*, a New Species from the Radiolarian Marls of Barbadoes; and the evidence it affords to the Age and Origin of those Deposits." By J. W. Gregory, Esq., F.G.S.

In this paper the discovery of a species of *Cystechinus* from the Radiolarian earth of Barbadoes was recorded. The specimen is now preserved in the National Collection, South Kensington. The form was described and distinguished from the three modern species which were found during the 'Challenger' Expedition. The latter have shown that the bathymetrical range of the genus is from 1050 to 2225 fathoms.

The author gave proofs that the specimen really came from the Radiolarian marl, and not from the overlying Coralline Limestone, and after discussing the age of the marl, as inferred by Prof. E.

Forbes, from an examination of the Mollusca, and by Prof. Haeckel after studying the Radiolaria, gave his reasons for supposing that it is in reality more modern than these authors supposed, and may be referred to the Pliocene or Pleistocene.

Though *Cystechinus crassus* possessed plates of greater thickness than those of the previously described species, the ambulacra were apetaloid, and the author concluded that though an inhabitant of seas of less depth than those in which the modern forms occur, it may be fairly considered to have been a dweller in deep seas, and to indicate that the Radiolarian deposit is a true deep-sea ooze.

CORRESPONDENCE.

A PALÆONTOLOGICAL RECORD.

Sir,—Now that Palæontology has become so complex a science, and new species are from day to day described in various parts of the world, is it not desirable that some International Record of them should be published at stated intervals?

We would suggest that the matter be taken up by the International Geological Congress; and if this be adopted, every one who describes a new species of fossil should send in the name and full references to the work in which it was published and figured, with accounts of the locality, geological horizon and biological order of the species.

In this way we should have an authentic register of new species, that would be of great value to all students of Palæontology; and, in short, "facilitate the preparation of that general list of all described fossils which is at present one of the greatest desiderata in geological science."[1]

Rudolf Schäfer.
Horace B. Woodward.

OBITUARY

HENRY WILLIAM BRISTOW, F.R.S., F.G.S.,

Late Director of the Geological Survey of England and Wales.

Born, May 17, 1817. Died, June 14, 1889.

THE name of H. W. Bristow will always be associated with the history of the Geological Survey, on which he served for a period of forty-six years. During the first few years of the official existence of the Survey, De la Beche had to depend to a large extent on voluntary or temporary assistance, but gradually he gathered around him a permanent staff of field-geologists and of others occupied in museum-work. Among those attached to the Survey in these early days were John Phillips, Ramsay and Aveline. In 1842 Mr. Bristow, then nearly twenty-five years of age, was appointed an Assistant Geologist, and during the next few years [Sir Warington] Smyth, Baily, Edward Forbes, Jukes, Selwyn and others joined the staff, whose headquarters were then situated in Craig's Court.

[1] See Address to the Geol. Soc. 1889, by W. T. Blanford.

Mr. Bristow was born on May 17th, 1817, and was educated at King's College, London, where, in 1840-41, he obtained certificates of honour in the departments of civil engineering and applied science. His father, Major-General H. Bristow, belonged to an old Wiltshire family, and had served in the Peninsular War.

Commencing Geological Survey work in the neighbourhood of Radnor, on the Old Red Sandstone and Silurian rocks, Mr. Bristow was shortly afterwards transferred to the Jurassic regions of Gloucestershire and Somerset, mapping portions of the Cotteswold Hills near Wotton-under-Edge and Chipping Sodbury, and of the Oolitic district near Bath. In these areas he received guidance from John Phillips and William Lonsdale. Still later he proceeded to the south coast, and working eastwards of Lyme Regis, he personally surveyed the greater portions of Dorsetshire, and eventually much of Wiltshire, Hampshire, and the Isle of Wight, and parts of Berkshire, Sussex, the Wealden area, and eastern Essex.[1]

In the course of this extensive survey all the subdivisions of the Jurassic, Cretaceous, and Lower Tertiary strata came under notice; and students who have subsequently paid attention to the structure of these tracts, whether along the fine cliff-sections of the Dorsetshire coast or inland over the Isle of Purbeck, the Ridgway, or Bridport, have borne testimony to the care and accuracy with which Mr. Bristow has depicted the geology. For it must be remembered that, excepting the small geological maps of Buckland and De la Beche, of Webster, Fitton, and Mantell, the detailed structure of the district had all to be unravelled. Nor was this a simple and easy task, considering the unconformable overlaps (or oversteps), and the effects produced by anticlinal disturbances and faults. In fact, no one, without actual experience of the process of geological mapping, can fully realize the amount of physical toil and mental labour involved in tracing the geological boundaries and faults in a region where so many subdivisions occur, and where they appear often in irregular and unexpected juxtaposition.

It is Mr. Bristow's field-work which will remain as a lasting memorial of his devotion to geological science. If his literary work on the Survey appears small, it must be remembered that in the early days of the Survey, the geologists were moved rapidly on from place to place, so that unfortunately little time was allowed for making detailed notes of the strata, and still less for observing the mode of occurrence of the organic remains. Mr. Bristow's intimate knowledge of the lithology of the stratified rocks is shown in the portions he contributed to the Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology.

The preparation of the Survey maps, however, was supplemented by numerous sections, longitudinal and vertical, which Mr. Bristow constructed with much skill and neatness to illustrate and explain the geology of the regions he had surveyed. The Purbeck Beds were especially illustrated in this way, and while the palæontology

[1] The Sheets of the Geological Survey Map on which Mr. Bristow was principally engaged, are Nos. 1, 5, 7, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 35, 36, and 56.

of these beds was studied by Edward Forbes, the strata themselves were measured in great detail by Mr. Bristow, partly in conjunction with the Rev. Osmond Fisher, and partly with the aid of Mr. Whitaker. In like manner sections of the Tertiary strata in the Isle of Wight were prepared, while the palæontology was worked out by Forbes. The results of this work were published by Forbes, while the geology of the whole island was afterwards described by Mr. Bristow. The task of his later years had been to prepare a new edition of his Geology of the Isle of Wight; and this is now nearly ready for publication, having been revised and considerably augmented by Messrs. C. Reid and A. Strahan, who have lately re-surveyed the island on the scale of six inches to a mile.

In later years other areas surveyed by Mr. Bristow were illustrated by Memoirs. In conjunction with Mr. Whitaker, parts of Berkshire and Hampshire were described, and Mr. Bristow also contributed notes to the Memoirs on the Geology of the London Basin, the Weald, and East Somerset.

Considerable attention was given to the Rhætic Beds by Mr. Bristow, and in company with Mr. Etheridge, he visited the principal sections in the south of England and Wales, measuring the beds in detail, and eventually publishing the records. At the suggestion of Sir Roderick Murchison, in 1864, Mr. Bristow recommended that the name Penarth Beds be applied to the British representatives of the Rhætic Beds. He subsequently was occupied for several years in mapping these strata in parts of Glamorganshire, Gloucestershire, and Somerset, at the same time revising the geological maps over the regions visited.

Notwithstanding his arduous out-door occupation Mr. Bristow utilized his leisure hours in the preparation of a "Glossary of Mineralogy," which was published in 1861. This book was at once well received, proving to be an exceedingly useful work of reference, from its convenient arrangement, and the accurate and concise information given. The author had made considerable progress towards a new edition of the work.

Other works of a more popular nature likewise engaged his attention. In 1869 a translation by him of L. Simonin's "La Vie Souterraine" was published, under the title of "Underground Life; or Mines and Miners," a work which was adapted to the then present state of British mining. Three years later (1872), he produced a translation of Louis Figuier's "World before the Deluge," contributing a fresh chapter on the Rhætic or Penarth Beds. In previous years Mr. Bristow had also written mineralogical articles for Brande's Dictionary of Science, and Ure's Dictionary of Arts, Manufactures, and Mines. He also largely assisted the late Mr. Damon in his Geology of Weymouth, contributing much general information and some sections of the strata.

It only remains to be mentioned that after five years' service on the Geological Survey, Mr. Bristow was in 1847 promoted to the rank of Geologist. Twenty years later (1867) he was appointed District Surveyor, taking charge of the southern counties. In 1872 he was made Director for England and Wales, during the tenure

of which office he saw the completion of the Geological Survey of the country on the one-inch scale. Retiring in July, 1888, he enjoyed but for a brief period his well-earned repose. A sudden stroke of paralysis was the immediate cause of his passing away, after a lingering illness, on June 14th, in his seventy-second year.

Mr. Bristow was elected a Fellow of the Geological Society in 1843, and of the Royal Society in 1862. Unfortunately afflicted with partial deafness, he was unable to hold free intercourse with his brother geologists; hence he seldom took part in the meetings of the Geological Society, although he served on the Council for a short time.

He received a Diploma from the Imperial Geological Institute of Vienna, and from the King of Italy the Diploma and Insignia of an officer of the Order of SS. Maurice and Lazarus. For several years, and until the close of his life, he was Examiner in Geology for the Science and Art Department.

LIST OF PAPERS AND GEOLOGICAL WORKS BY H. W. BRISTOW.

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1861.—3. A Glossary of Mineralogy. 8vo. pp. xlvii. 420. London.

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5. Notes on the Auriferous Mines and Deposits of the Spanish and Portuguese Estremaduras. Mining and Smelting Mag. vol. ii. pp. 97–100, 132–135.

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1872.—10. Table of British Sedimentary and Fossiliferous Strata. The Description of Life Groups and Distribution. By R. Etheridge. London.

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13. Notes on his Survey of the [Brixham] Cave. Phil. Trans. vol. clxiii. pp. 496–497.

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1880.—15. Geological Map of England and Wales (founded on the Map published by the Society for the Diffusion of Useful Knowledge). Part 4 of Letts's Popular Atlas. London.

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1862.—17. H. W. Bristow and W. Whitaker, The Geology of Parts of Berkshire and Hampshire. Geol. Survey Memoir. 8vo. London.

1869.—18. H. W. Bristow and W. Whitaker, On the Formation of the Chesil Bank. Geol. Mag. Vol. VI. pp. 433–438, 574, 575.

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H. B. W.